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HANDBOOK OF INSTRUCTIONS
FOR
DIGITAL TO ANALOG CONVERTER
MEC MODEL 1576

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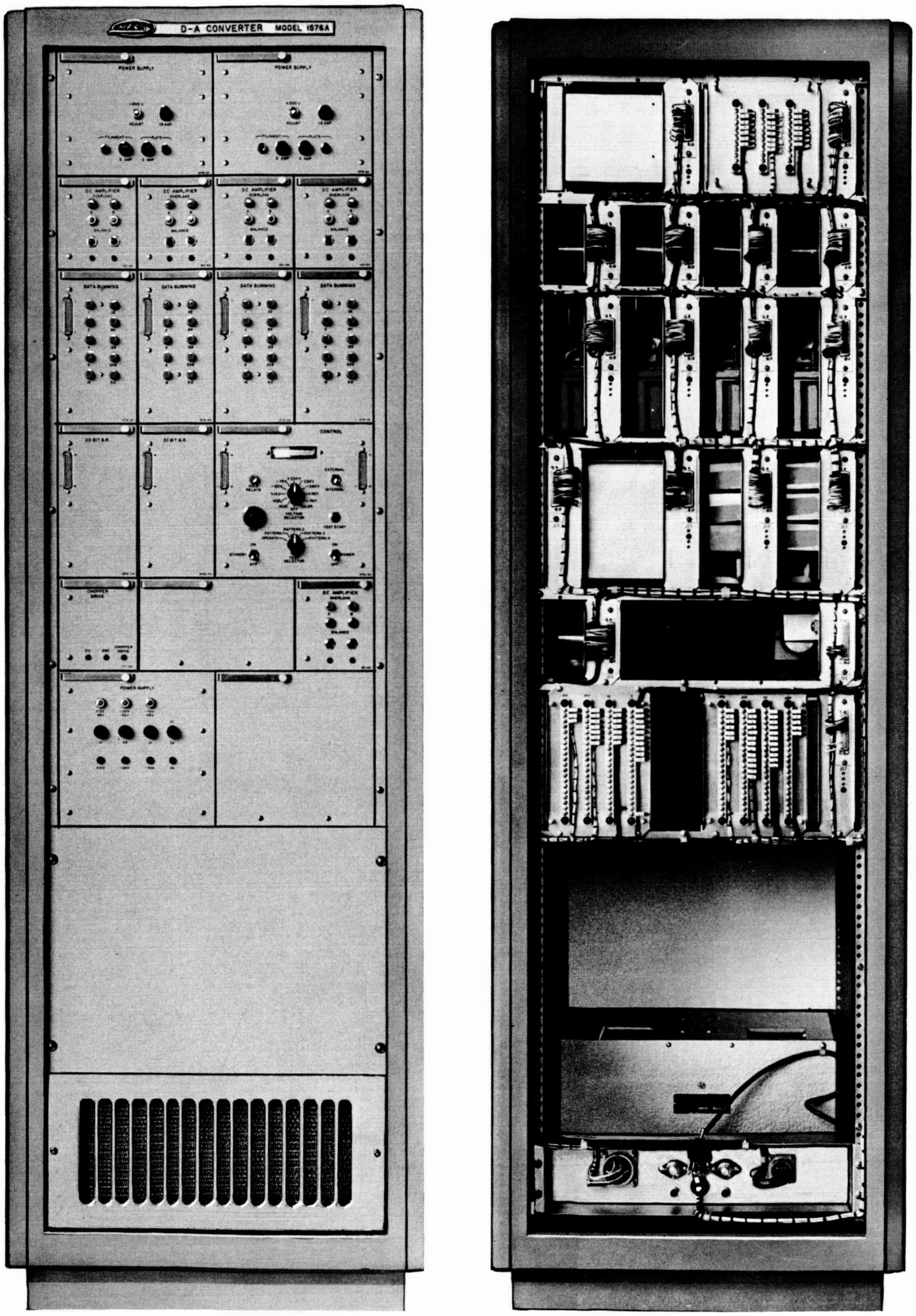


Figure 1-1. MEC Model 1576 D-A Converter

CHAPTER I
INTRODUCTION

1-1. PURPOSE OF THE EQUIPMENT

The Milgo Electronic Corporation (MEC) Model 1576 Digital to Analog Converter receives the serial data output from a Computer, and converts this data into four channels of analog outputs with the necessary reference voltages suitable for the inputs of a high speed analog plotting board.

1-2. SCOPE OF THE MANUAL

This instruction manual describes the MEC Model 1576 Digital to Analog (D-A) Converter, designed and manufactured by MEC for the International Business Machines, Federal Systems Division, Kingston, New York, in conjunction with Project Mercury.

1-3. PURPOSE OF THE MANUAL

This instruction manual is provided as an aid to better understanding of the operation and theory of the MEC Model 1576 D-A Converter and its associated equipment. It offers a complete technical explanation coupled with applicable illustrations. It is definitely necessary that the operator, or any person involved in the operation of this equipment, thoroughly read and understand the contents of this manual.

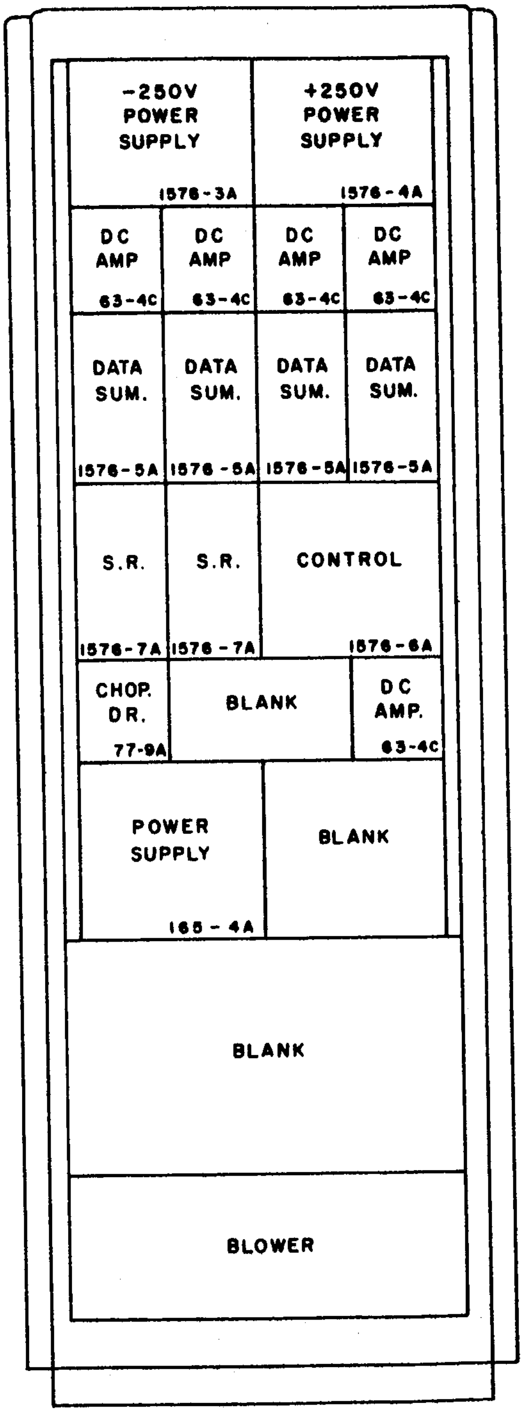


Figure 1-2. Chassis Arrangement

CHAPTER II
GENERAL DESCRIPTION

2-1. PHYSICAL DESCRIPTION

The D-A Converter is housed in a single relay rack approximately 24" wide, 22" deep, and 74-1/8" high. Its weight is approximately 660 pounds. All chassis are of modular construction and employ 50 pin connectors for the connection of each chassis to the rack wiring. The location of each chassis is illustrated in figure 1-2. One +250 volt Power Supply (MEC Model 1576-4A) is located at the top of the rack, and directly beside it is a -250 volt and -560 volt Power Supply (MEC Model 1576-3A). These Power Supplies furnish the necessary operating voltages for the DC Amplifiers in the rack. Directly below the Power Supplies are found one row of four DC Amplifier Chassis, MEC Model 63-4 C. These four DC Amplifiers are used in conjunction with the four Data Summing Chassis, MEC Model 1576-5A, found in the third row of chassis. The fourth row of chassis consist of two 20 Bit Shift Registers, MEC Model 1576-7A, and a Control Chassis, MEC Model 1576-6A. The fifth row houses the Chopper Drive Chassis, MEC Model 77-9A, and one DC Amplifier Chassis used to provide the analog plus and minus reference voltages for this system. Located directly below the Chopper Drive Unit is one transistor Power Supply, MEC Model 165-4A. This Power Supply furnishes +12 volts, -20 volts, and -70 volts for the transistor circuitry throughout the D-A Converter. A two speed Blower capable of delivering 500 cubic feet per minute of filtered room air for internal rack cooling is located at the front lower portion of the D-A Converter Rack, and should be operated at high speeds at all times during the operation of the equipment. In the lower rear of the rack is a mounting bracket on which all input and output connectors are located. The input a-c fuses and master a-c power switch are located on the same panel. The D-A Converter normally operates from two phases of a 115 vac ±10%, 60 cycles ±5, three phase system; however, it may be operated from single phase 115 vac, 60 cycles by connecting input phases 1 and 2 together on the input power connector J19. The input current for both phase 1 and phase 2 is 4 amperes.

2-2. INPUT SIGNALS

There are three input lines to this D-A Converter; the "select and ready" line, the "sample" pulse line, and the data line. The "select and ready" line is a control signal with which the computer signifies to the D-A Converter that it has data to present. A return signal from the D-A Converter, called the "D-A ready", informs the computer that the D-A Converter is prepared to read the next bit of data. The data input to this D-A Converter consists of 40 bits of serial data, which are transmitted over the data input line from the Digital Computer. Each time a new data bit is presented on the input data line and the "D-A ready" signal indicates that the D-A Converter is prepared to read the new bit of data, a "sample" pulse is sent to the D-A Converter from the Computer. There must be a "D-A ready" pulse and a "sample" pulse for each bit of data received from the Computer. A significant or "1" level on any of the three lines from the Computer will be +6.7 volts ±.5 volts. A non-significant or "0" level from the computer is 0 volts ±.5 volts. A +35 volts external reference voltage input is provided so that an external reference voltage may be applied to the D-A Converter when it is operating with associated analog equipment. If a +35 volts reference source is not available, the Converter is capable of generating its own internal +35 volts and -35 volts reference voltages.

2-3. OUTPUT SIGNALS

There are four individual channels of analog voltage outputs. The output voltage may swing from +35 volts to -35 volts; +35 volts representing an input digital signal pattern of all "1"s, and -35 volts representing an input signal pattern of all "0"s. In addition, internally generated reference voltages of +35 volts and -35 volts are provided at the outputs to furnish reference voltages for other associated analog equipment. There is, in addition, a "D-A ready" output to the digital computer which is one of the inter-system control signals. A 0 volt ±.5 volt level indicates that the D-A is ready to receive the next bit of data, and a -8 volt ±2 volt level indicates that the D-A is not ready.

CHAPTER III
THEORY OF OPERATION

3-1. GENERAL (Figure 9-1.)

3-1.1. Digital data bits are received by the D-A Converter through the digital input plug, J20, which is located at the rear of the base of the D-A Converter Rack. Along with the data input there are three control signals which are used so that this data may be properly brought in to the D-A Converter, these signals being: a "select and ready" input provided by the Computer to signify that the Computer has data available; a "sample" input, which is a signal generated by the Computer to signify that the new data bit has been presented on the data line ; and a "D-A ready" which is generated by the D-A Converter so that it can signify to the Computer that it is also ready to receive the next data bit. These signals are graphically shown on the timing diagram of the Computer Control signals in figure 3-1. There are a few requirements on the timing of the "data", "sample", "select and ready" and "D-A ready" inputs. There is a total of N+1 "D-A ready" signals (N = number of input data bits) provided by the D-A Converter; therefore, there would be a total of 41 pulses. The timing between these pulses is determined by the Control Chassis and is approximately 250 microseconds. The "select and ready" will remain up (+8 volts) during the complete time in which the data is being provided. As shown in figure 3-1, there is a minimum and maximum timing between the "data", "D-A ready" and the "sample" pulses, and these minimum and maximums must be maintained for proper operation of the system.

3-1.2. There is a total of 40 serial input data bits which are received through the Control Chassis and are shifted through two 20 Bit Shift Registers in series, giving a total capacity of 40 serial bits of information. The shifting and controlling of these 40 data bits is accomplished by the Control Chassis. This particular phase of the Control Chassis's operation is explained in detail in paragraph 3-2, "Control Chassis". The "sample" input is used to tell the Control Chassis that a new data bit is available and should be received into the cores. After the last data bit has been received and sampled, the last "D-A ready" will go out to the Computer to signify to the Computer that the complete word has been received. Then the Computer will drop the "select and ready" line to 0 volts. The "select and ready" line will have been at a +8 volt d-c level for approximately 10 1/2 to 11 milliseconds. This time is determined by the accuracy of the 250 microsecond interval between each "D-A ready" pulse.

3-1.3. When the serial 40 bits of data have been put into storage in the 40 cores found in the two 20 Bit Shift Registers, a pulse is generated by the fall of "select and ready" which produces the necessary pulses to parallel transfer this data into 40 transistorized flip-flops. The outputs of these 40 flip-flops control the operation of four groups of 10 relays each. Each group of relays is found in a Data Summing Chassis. The input 40 bit word is actually four different 10 bit words, one directly behind the other. The input format from the Computer is least significant bit (LSB) first, with the first 10 bits being Y2, the second 10 bits being X2, the third 10 bits being Y1, and the last 10 bits being X1. The output of these flip-flops is wired to the appropriate relay so that the data format will be presented to the Data Summing Chassis for analog conversion in the proper sequence. The most significant bit (MSB) of digital data is applied to relay K502 of the binary converting Data Summing Chassis. These 10 bit binary words control the flip-flops which

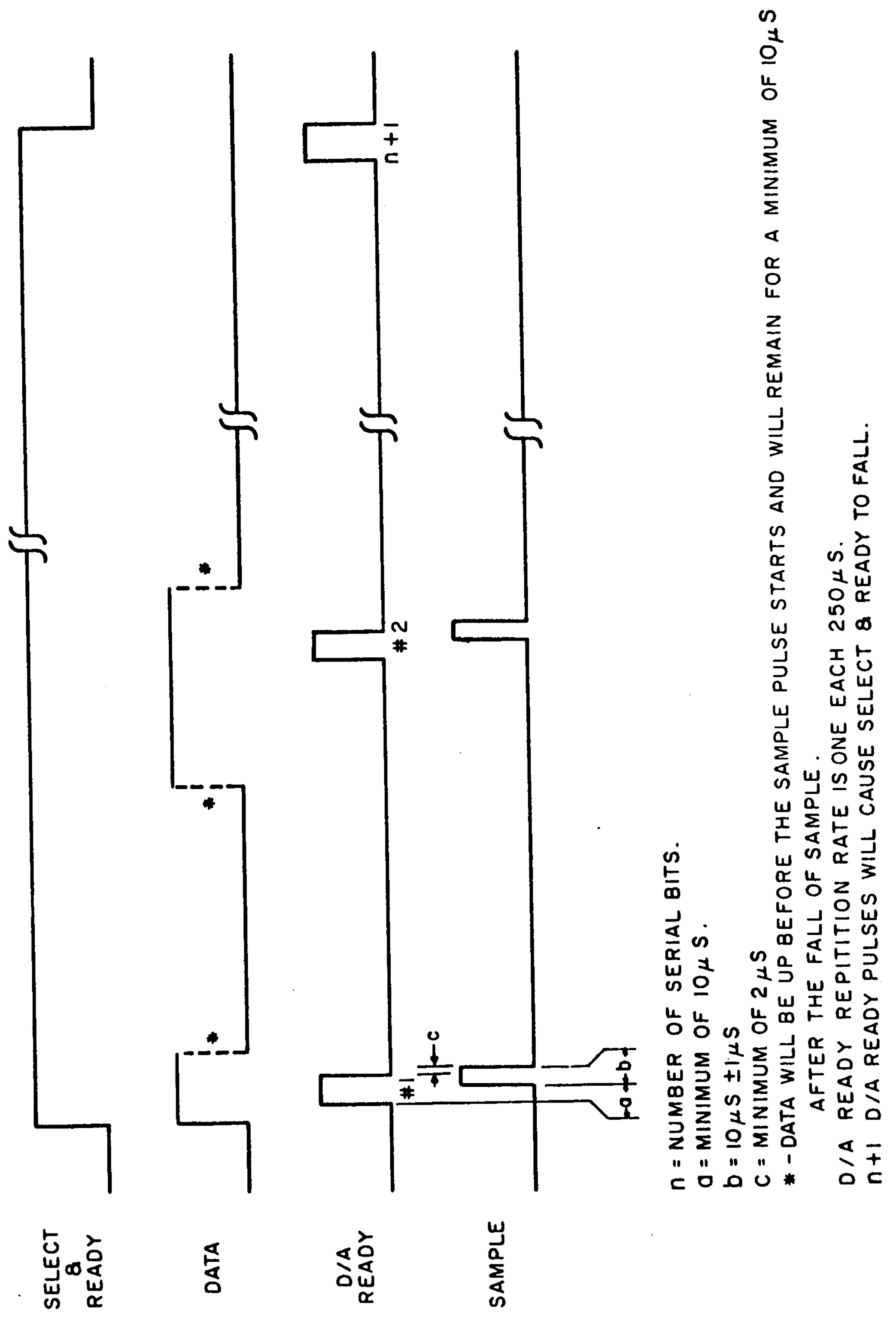


Figure 3-1. Computer Control Signals

control the relays which are connected to the feedback resistor to the DC Amplifiers. These DC Amplifiers produce an analog output voltage which is directly apportioned to the binary count of the input serial digital word. The Control Chassis produces a reset trigger which resets all the flip-flops into a "0" condition. Then in approximately 10 microseconds, the new data is inserted into the same flip-flops. At this time, some relays will take on a new condition for the new analog output, but because some relays will open or close sooner than others depending upon the mechanical time delay within the relays, a signal called "D-A hold" is provided. This signal operates relay K501 in each Data Summing Chassis in such a manner that during 4-1/2 milliseconds of time, a set of contacts of the relay are open and the DC Amplifier involved will hold its previous charge for this length of time. Therefore, the analog output will be a smooth change when the new condition is inserted by the new data word. Figure 9-1 illustrates graphically the complete operation of the Control Chassis, each plug-in transistor network, and the two 20 Bit Shift Registers with their associated flip-flops. Figure 9-1 also shows the 40 relays which are used to control the feedback resistors which control the analog output voltage. The four analog outputs are used for the operation of a plotting board. One group, X1 and Y1, are used for the operation of one of the arms of a plotting board and the other outputs, X2 and Y2, are for the operation of the other arm of the same plotting board. This allows two arms to plot two different input data at the same time. Another provision of this equipment is that it provides a +35 volt reference output and a -35 volt reference output which is used for the operation of this rack in making the necessary analog conversions. External outputs of these reference voltages are provided for the use of associated analog equipment.

3-1.4. There is an INTERNAL-EXTERNAL reference switch on the Control Chassis which can provide for an internally generated +35 volt reference voltage or, when in the EXTERNAL position, allows this equipment to slave the reference amplifiers to an externally generated reference voltage, which must be +35 volts dc.

3-2. CONTROL CHASSIS, MEC MODEL 1576-6A (figures 9-12 and 9-13)

3-2.1. Functions - The purpose of the MEC Model 1576-6A Control Chassis is for the control and operation of the following functions:

a. It provides the STAND-BY and POWER switches (S604 and S605) so that with the STAND-BY switch turned on, only filament power may be supplied to the vacuum tube portion of the system to give the filaments warm-up time before B+ voltage is applied. The POWER switch turns on the rest of the a-c power which turns on the B+ voltage to the vacuum tubes, and also turns on the transistor voltage supplies (165-4A) so that the digital portion of the D-A Converter can operate.

b. It provides a monitoring meter (MV601) with a selector switch (S603) so that both phases of the input a-c power and the outputs of the various power supplies may be monitored on the indicating meter. Also provided for monitoring purposes, is the + and the - reference voltages and the output from the Chopper Drive. The resistors in series with the meter have been chosen so that the meter will register a reading of 10 for normal voltages which should be encountered at the monitoring circuit. Since most of the power supply voltages have adjustments on them, they can be adjusted to the exact reading of 10 on the meter. The readings from these power supplies should be within approximately $\pm$ 2% of the 10 reading on the voltmeter.

c. The Control Unit provides the operation and choice between an external and an internal reference supply for the analog portion of the equipment. When the switch, S606, marked INTERNAL, EXTERNAL on the front panel is in the EXTERNAL position, it allows the external reference voltage input (which must be at a 35 volts), to enter plug 602, pin 10, which enters pin 4 of resistor network RN44. R4 of the resistor network provides the input resistor to the #1 Amplifier. R5 is an unloading resistor which provides an unloading current so that there is negligible current drawn from the external reference input. R1 provides the feedback resistor for amplifier #1. Since the ratio of R1 to R4 is "1", the gain of this amplifier is 1.00 and the output will be -35 volts. Resistor R2 and R3 provide the input and feedback resistor for

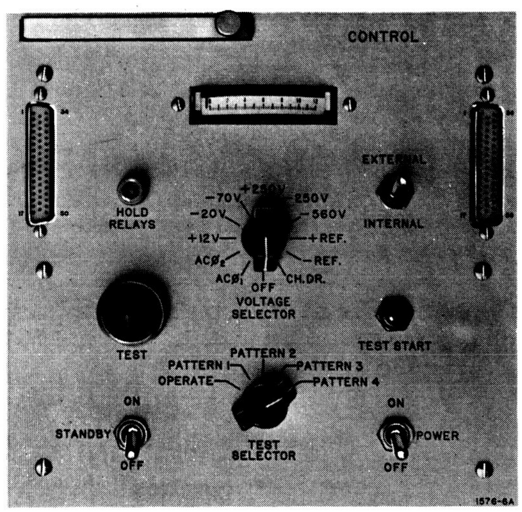


Figure 3-2. Control Chassis

amplifier #2, which develops on its output +35 volts. Capacitors C624, C625 and C626 are used for stabilization of the amplifiers. When switch S606 is in the INTERNAL position, the D-A Converter will develop its own reference voltage with the aid of an internal reference standard cell, SC601. When in this position, R1 is in series with R6 located within the network RN44. Connected to the junction of these two resistors is the standard cell SC601, which is in series with the input of the DC amplifier. Since the input to the DC amplifier has very little input grid current, the drain upon this standard cell is negligible, and therefore its output is very stable. This cell will operate a very long time without the need of replacement, since there is almost no current drained from the standard cell.

d. The rest of the Control Chassis is used for the purpose of controlling the output from the Computer which is furnishing the input data which will be converted from digital to analog. This portion of the Control Chassis performs the necessary operations so that the data consisting of 40 input serial bits may be detected and shifted into a serial shift register. It also controls the parallel transfer of the serial data into transistorized flip-flops which will operate the relays found in the Data Summing Chassis.

3-2.2. In the following discussion of the digital operation portion of the Control Chassis, continual reference to Figures 9-1 and 3-1 is recommended. If switch S601A is in the OPERATE position, the change of "select and ready" impulse from a d-c level of 0 volts to +8 volts, is applied through resistor R602 to pulse amplifier N601A. The output of N601A is at -20 volts when "select and ready" is a "1" (+8 volts). The output of N601A has three functions. The first (through diode CR601 to one-shot N602) and the second (through capacitor C633 and diode CR632 to flip-flop N606) come into effect only when the "select and ready" input falls from +8 volts to 0 volts and will be considered at that time. The third function of the N601A output is to drive pulse amplifier N601B, where it is amplified and used to trigger flip-flop N606 through an open "and" gate consisting of capacitor C627, resistors R610 and R657. This "and" gate remains open except during a one millisecond period following the drop of "select and ready" and is controlled by the output of one-shot N602. Since at this time this one-shot N602 is not triggered, the "and" gate is open and the flip-flop N606 is triggered. The pin 8 output of flip-flop N606 is applied through an "and" gate, consisting of CR604 and CR605, to emitter follower N607B which forms the "D-A ready" signal to the Computer. The output voltage of this pulse is 0 volts for a "1" and -8 volts ±2 volts for a "0". The "D-A ready" signal will remain in a "1" condition until a "sample" pulse is received. When the "sample" pulse is received on pin 5 of the input plug (P601), it triggers pulse amplifier N608 (provided that "select and ready" is in a "1" condition as this input goes through an "and" gate consisting of CR608 and CR609). The output to pulse amplifier N608 is at -20 volts during the time the "sample" pulse is a "1", and is coupled through resistor R623 and capacitor C611 to pulse amplifier N608B, which develops 0 volts during the time the "sample" pulse is a "1". This 10 microsecond "sample" pulse triggers one-shot N609, producing a 9 microsecond output. The positive going pin 7 output, which has no delay, restored flip-flop N606 to the "0" condition, thus dropping the "D-A ready" signal. The "D-A ready" signal will drop to a "0" or minus 8 volts in approximately 2 microseconds. The delayed output of one-shot N609 (9 microseconds) passes through an "or" gate consisting of diodes CR610 and CR611 and triggers 130 microsecond one-shot N610, which with no delay drives the core driver (N611) which will shift the first bit of data through the shift register by one core. The delayed output of N610, which is delayed by 130 microseconds, then triggers one-shot N605. After 120 microseconds the delayed output of N605 will go through capacitor C608 and diode CR628 (an "or" gate) and trigger flip-flop N606 to the "1" condition, thus developing the second "D-A ready" pulse. The next "sample" pulse will go through as the previous one did and repeat the performance. That is, when it arrives it will turn off "D-A Ready" and after a total of 250 microseconds delay (one-shot N610 plus one-shot N605) will once again turn on the "D-A ready" signal. This operation will repeat for the total number of data bits and "sample" bits. It can be seen that since "select and ready" developed the first "D-A ready" and "sample" pulses developed the rest, there will be a total of one more "D-A ready" signal than there were "sample" pulses. The Computer from which this D-A Converter is receiving data will use the last "D-A ready" signal as a disconnect signal and will drop "select and ready" with this signal. When "select and ready" is dropped, a positive pulse is produced on pin 4 of pulse amplifier N601A and performs two functions. First, the pulse passes through capacitor C633 and diode CR632 and resets flip-flop N606 to the "0" state. With the output of N606 removed from the "and" gate composed of diodes CR604 and CR605, emitter follower N607B is turned off and prevents any "D-A ready" signals from being sent to the computer. The second function of the positive pulse from N601-4 is to trigger one millisecond one-shot N602, which in turn triggers 4.5 millisecond one-shot N603, which produces the "D-A hold" pulse. The delayed pulse on pin 5 of one-shot N602 serves two functions: (a) it prevents any "D-A ready" signals from being generated during this 1 millisecond time, and (b) it triggers one-shot N604 after the delay of 1 millisecond. One-shot N604 produces the "reset trigger" and "data gate trigger" necessary for the shift registers to transfer data. These two pulses will be discussed in detail in paragraph 3-2.4.

3-2.3. The data input (a d-c level) is applied to the input of emitter follower N607A through an "and" gate consisting of diodes CR502, CR613 and CR614. The other input of the "and" gate is the output of one-shot N609 which was triggered with the "sample" pulse. Therefore, if data is a "1" (0 volts) when "sample" triggers N609, the output from emitter follower N607 will insert the "1" data into core M603. Immediately after data is inserted, a core drive pulse from N611 which was triggered by one-shot N609 through one-shot N610 shifts the data bit through pin 14 of plug P601 to the input of a 20 Bit Shift Register. There is a total of 40 input data bits with 40 "sample" pulses used to develop 40 shift pulses to accumulate this data into the series combination of two 20 Bit Shift Registers.

3-2.4. The two signals mentioned previously called "reset trigger" and "data gate trigger" operate on the 20 Bit Shift Registers in the following way. The "reset trigger" resets all the data flip-flops to the "0" condition and the "data gate trigger" produces a 50 microsecond gate which allows the data from the cores to be parallel transferred to the flip-flops. For details on this operation see the write-up on the 20 Bit Shift Register found in paragraph 3-5. In order that this data be parallel transferred, one more core drive pulse is required so that the output of the cores can be superimposed upon the gate pulse thus triggering the flip-flops into the necessary data pattern. This core drive pulse is generated by the delayed output of one-shot N604 which produced a 6 microsecond delay during the same time in which it produced the "reset trigger" and "data gate trigger". This delayed pulse triggers one-shot N610 through an "or" gate consisting of diodes CR611 and CR610 which triggers core driver N611. All other core drivers are triggered at the same time by N611, and thus a core drive pulse is generated 6 microseconds after the "data gate" pulse went to the "1" condition and the new data word from the output of the cores is now inserted in parallel into the data flip-flops which are used in conjunction with the Data Summing Chassis and DC Amplifiers to produce the analog output. The system is then ready to start the cycle over again when the "select and ready" signal goes to a "1".

3-2.5. N612, N613, N614, N615, and N616 are used in order only to develop test signals. When in any of the test positions of the switch, S601, that is, positions 2, 3, 4, and 5 of this switch, the test circuitry is allowed to operate in the following way. It provides a voltage to pushbutton switch S602 which allows the operator, when this pushbutton is pushed, to trigger 25 millisecond one-shot N612. The positive going output from pin 7 of this one-shot will trigger flip-flop N614 to the "1" condition, and 25 milliseconds later the delayed output from pin 5 of one-shot N612 will open an "and" gate consisting of resistor R637 and R638 so that the next pulse which is coupled through capacitor C621 from the output of N616 through S601C and CR622, may trigger flip-flop N614 to the "0" condition. This will produce on the output of this flip-flop a signal which is approximately 25 milliseconds long and is keyed to the output of the "test data" generators. The output of N614 generates the "test select and ready" and is applied to its input through diode CR620 and switch S601A. The delayed output from one-shot N612 also triggers one-shot N613, which in 100 milliseconds will produce a pulse which goes through capacitor C619 and diode CR617 and re-triggers one-shot N612 so that the test cycle may be repeated. The rising edge of the "select and ready" pulse as described earlier develops a "D-A ready", therefore the "test select and ready" will do likewise. This "D-A ready" goes through switch S601D and thus triggers 10 microsecond one-shot N615. This produces a 10 microsecond pulse on pin 7 which produces the next "test sample" pulse, which after a series of events (250 microseconds) produces another "D-A ready" which will produce the next "test sample" etc. The output of N615 which has been delayed for 10 microseconds, triggers counter flip-flop N616, which is producing alternate "1" and "0" for the "test data" input. The selection of either a "0-1" pattern or a "1-0" pattern is conditioned by switch S601C which determines at which time the "select and ready" signal will fall. Switch S601C as shown on the right hand side of flip-flop N616 determines if a "0-1", a "1-0" or all "1" or "0" pattern will be provided for the "test data" input. When the switch is in the second position, in which it is at -20 volts, an all "0" pattern will be formed. When in the next two positions, alternate "1"s and "0"s will be formed; when in the last position, which is 0 volts, an all "1" pattern will be developed. Zener diode CR623 adds a +10 volts to this signal and thus it can be seen for a "1" a +10 volts has been generated since +10 volts is a "1". This satisfies the conditions necessary to insert "test data" in lieu of "data" from the Computer. Indicating light DS601 will blink for 4-1/2 milliseconds each time a complete word has been received from the Computer and also indicates that the hold relays are in a hold condition.

3-3. D-A CONVERSION

3-3.1. A simplified block diagram of the D-A Conversion system of one channel of the D-A Converter is illustrated in Figure 3-3. All items illustrated in this figure are contained in the portion of the rack associated with one channel which consists of 1 DC Amplifier, 1 Data Summing Chassis and 1/2 of a 20 Bit Shift Register. The DC Amplifier which is associated with the Data Summing Chassis is placed directly above it. The Shift Register is located beneath the Data Summing Chassis. The first 20 Bit Shift Register is used to operate the first two Data Summing Chassis from the left side of the rack, and the second 20 Bit Shift Register is used to operate the right hand two Data Summing Chassis.

3-3.2. Associated with Amplifier A is an input resistor R501 denoted R_i, and 10 binary weighted feedback resistors R502 to R511 denoted R_b. Across each individual binary weighted resistor is an individual relay contact associated with the relays. Shown above each relay in figure 3-3 is a destination corresponding to the binary weight of each feedback resistor. The smallest resistor R511 corresponds to a binary weight of 1, and the largest resistor R502 corresponds to a binary weight of 512. The output voltage of Amplifier A(E_A) may be calculated from the following formula: $E_A = -E_R \frac{R_b}{R_i}$. This formula states that the output voltage of a DC Amplifier is equal to the negative of the input voltage times the ratio of the feedback resistor to the input resistor. Relays K502 through K511 may be activated in such a way that the feedback resistance can vary between 0 ohms and 12, 487.75 ohms in 12.2 ohm steps, resulting in output voltage changes between 0 volts and -34.9658 volts in 34.2 millivolt increments at the output of Amplifier A. This 34.2 millivolt figure may be obtained by substituting in the preceding formula the values of E_R, R_b, and R_i in the following manner:

$$E_A = -35 \times \frac{12.2}{12,500} = -0342 \text{ volts or } -34.2 \text{ millivolts}$$

R_b (feedback resistance) is the only value of resistor R511 in this particular case.

3-3.3. Table 3-1 contains several representative analog outputs corresponding to various relay closures in the feedback circuit of Amplifier A. From this table, it can be seen that when all relay contacts are open, the total binary weight is 1023 and the output voltage E_A at this time is -34.9658 volts. If only the contacts of relay K502 are open, the binary weight is 512 and the output of the amplifier is -17.5 volts. To obtain a binary weight of 1 bit less, that is 511, relay K502 should be closed and relays K503 through K511 should be open. Voltage E_A now changes from -17.5 to -17.4658 volts (a difference of 34.2 millivolts). If all relay contacts are closed, all feedback resistances are shorted out and the output voltage E_A becomes 0 volts. When only relay K511 is open, the smallest bit is inserted into the system and the output voltage of the amplifier becomes -.0342 volts.

TABLE 3-1

D-A CONVERSION

TOTAL BINARY WEIGHT	OPEN RELAY CONTACTS	INDICATORS ON	R_b	E_A	E_B
1023	All	All	12, 487. 75Ω	-34. 9658v	+34. 9658v
511	K503-K511	256, 128, 64, 32, 16, 8, 4, 2, 1	6, 237. 8Ω	-17. 4658v	- . 0342v
512	K502	512	6, 250Ω	-17. 5v	+ . 0342v
449	K503-K505 K511	256, 128, 64 1	5, 480. 95Ω	-15. 3467v	- 4. 2724v
448	K503-K505	256, 128, 64	5, 468. 75Ω	-15. 3125v	- 4. 3408v
0	None	None	0Ω	0v	-34. 9658v
1	K511	1	12. 2Ω	- . 0342v	-34. 9316v

3-3. 4. It is obvious that any binary weight between 0 and 1023 can be obtained by combinations of the various relay closures. For example, if a binary weight corresponding to 448 is desired, it may be obtained by opening relays K503, K504 and K505, which results in a feedback resistance of 5468. 75 ohms and the output voltage of amplifier A becomes -15. 3125 volts as illustrated in Table 3-1. If the next higher bit, 449, is desired, relays K503, K504, K505, and K511 should be opened. The feedback resistance will now be 12. 2 ohms greater (5, 480. 95 ohms) and the output voltage will be . 0342 volts greater (-15. 3467 volts).

3-3. 5. In addition to the previously described components of the D-A Conversion System are the holding relay K501 and the B amplifier with its associated input and feedback components. The holding relay K501 is a mercury-wetted, polarized, high speed relay used to disconnect the input to the B amplifier during the time the digital pattern is changing. The holding relay signal is triggered by the arrival of the "read-in" pulse (approximately 5 millisecond duration) which energizes the holding relay; the holding relay then opens the input to the B amplifier. The B amplifier output is prevented from decaying to 0 volts by the . 5 microfarad capacitor C502, which holds the output to approximately the same voltage established by the feedback resistor pattern from the previous frame. The new data signal pattern is applied in parallel to the ten flip-flops which in turn operate the ten relays in the Data Summing Chassis. After the relays have repositioned, and have set up a new "1"-"0" feedback resistor pattern (approximately 1 millisecond) the holding relay signal ends, de-energizing the holding relay and reconnecting the input to the B amplifier. The output of the B amplifier is derived from the following equation:

$$E_B = -E_A \frac{R513}{R512} - E_R \frac{R513}{R514} = -E_A\left(\frac{100,000}{50,000}\right) - 35 \left(\frac{100,000}{100,097.7}\right) \text{volts}$$

$$E_B = -(2E_A + 34.9658) \text{ volts}$$

3-3. 6. Examples of D-A Conversion

3-3. 6. 1. Example A - Assume a signal pattern consisting of all "1"s is received by the Converter in one channel. Relays K502 through K511 are energized and R_b consists of the series equivalent of resistors R502 through R511.

The output of amplifier A is derived by:

$$E_A = -E_R \frac{R_b}{R_i} \text{ volts}$$

$$E_A = -35 \left(\frac{12,487.75}{12,500}\right) \text{volts}$$

$$E_A = -34.9658 \text{ volts}$$

The output of the amplifier B is derived by:

$$E_B = -(2E_A + E_R \frac{R513}{R514}) \text{ volts}$$

$$E_B = -\left[2(-34.9658) + 34.9658\right] \text{ volts}$$

$$E_B = +34.9658 \text{ volts}$$

Therefore, for a signal input pattern consisting of all "1"s, the output of one analog channel is +34.9658 volts, which is within the specified system accuracy of 68.4 millivolts (1 binary digit).

3-3.6.2. Example B - Assume a signal pattern of all "0"s is received by the Converter in one channel. Relays K502 through K511 remain closed and R_b is equal to 0 ohms. The output of the A amplifier is therefore:

$$E_A = -35 \times \frac{0}{12,500} \text{ volts}$$

$$E_A = 0 \text{ volts}$$

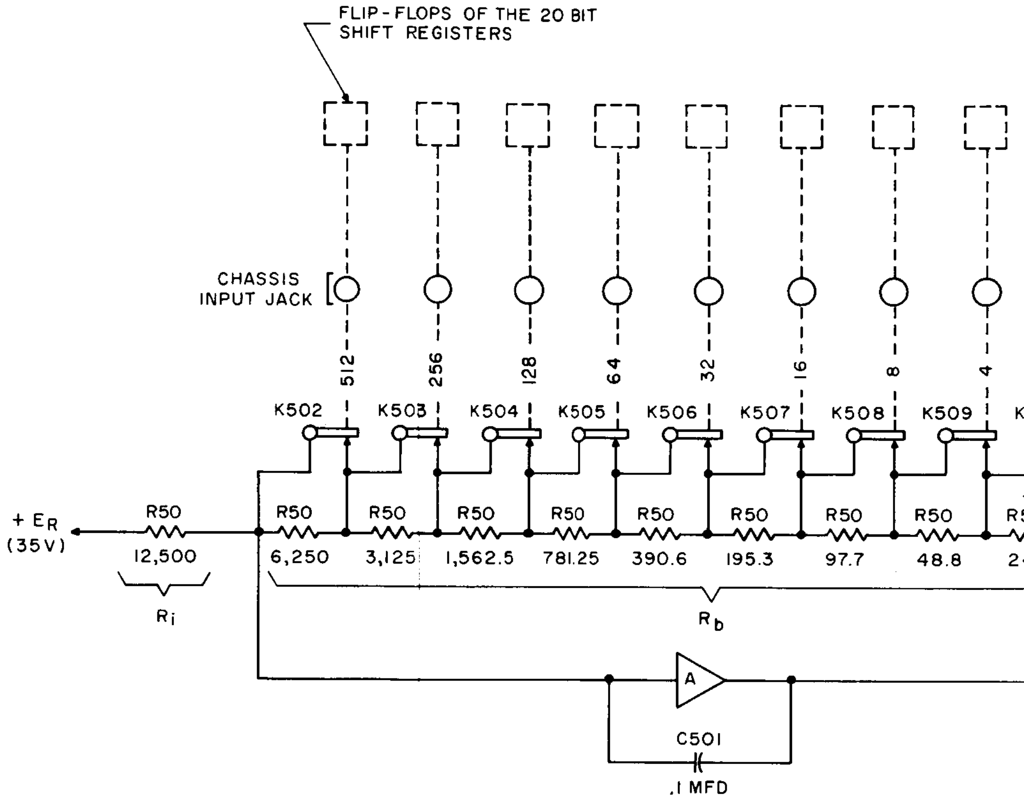
The output of the B amplifier is:

$$E_B = -(0 + 34.9658) \text{ volts}$$

$$E_B = -34.9658 \text{ volts}$$

Therefore, for a signal input pattern of all "0"s, the output of one analog channel is -34.9658 volts. For further comparison of E_A and E_B versus data inputs, see Table 3-1.

3-3.6.3. Visual indication of the energized Data Summing relays is provided by means of neon lamps mounted on the front panel of each Data Summing Chassis. The column titled "Indicators On" of Table 3-1 pertains to these neon lamps.



$$E_A = -E_R \frac{R_b}{R_i} \text{ VOLTS}$$

$$E_B = -(2\,E_A + 34.9658) \text{ VOLTS}$$

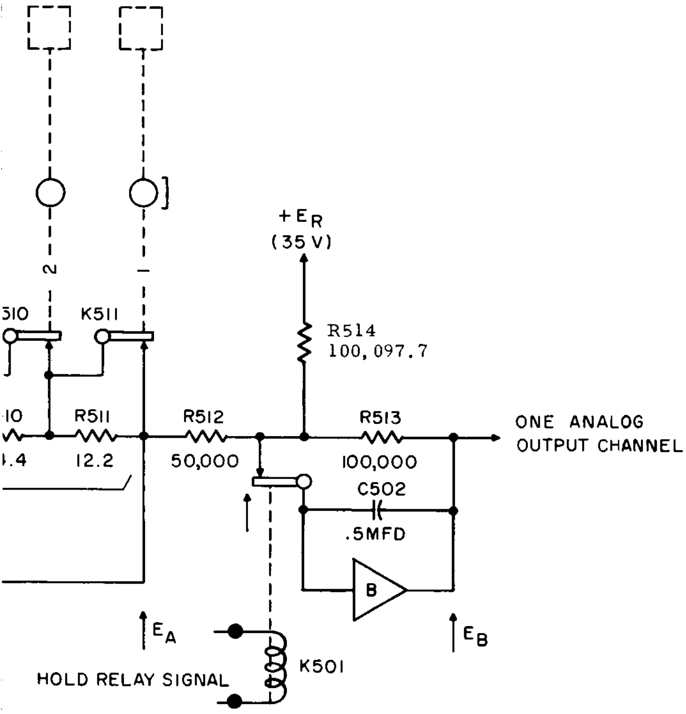


Figure 3-3. D-A Conversion

Dwg. #CPD1472

3-4. DATA SUMMING CHASSIS, MEC MODEL 1576-5A (Figures 9-3 and 9-4)

3-4.1 General - The components of the Data Summing Chassis are suitably packaged to facilitate easy plug-in to a mating assembly located in the rack. Resistor R501 through R514 are mounted in a sealed silicon oiled filled aluminum casting located in the chassis as illustrated in figure 3-4. Connections to circuitry located within this container are

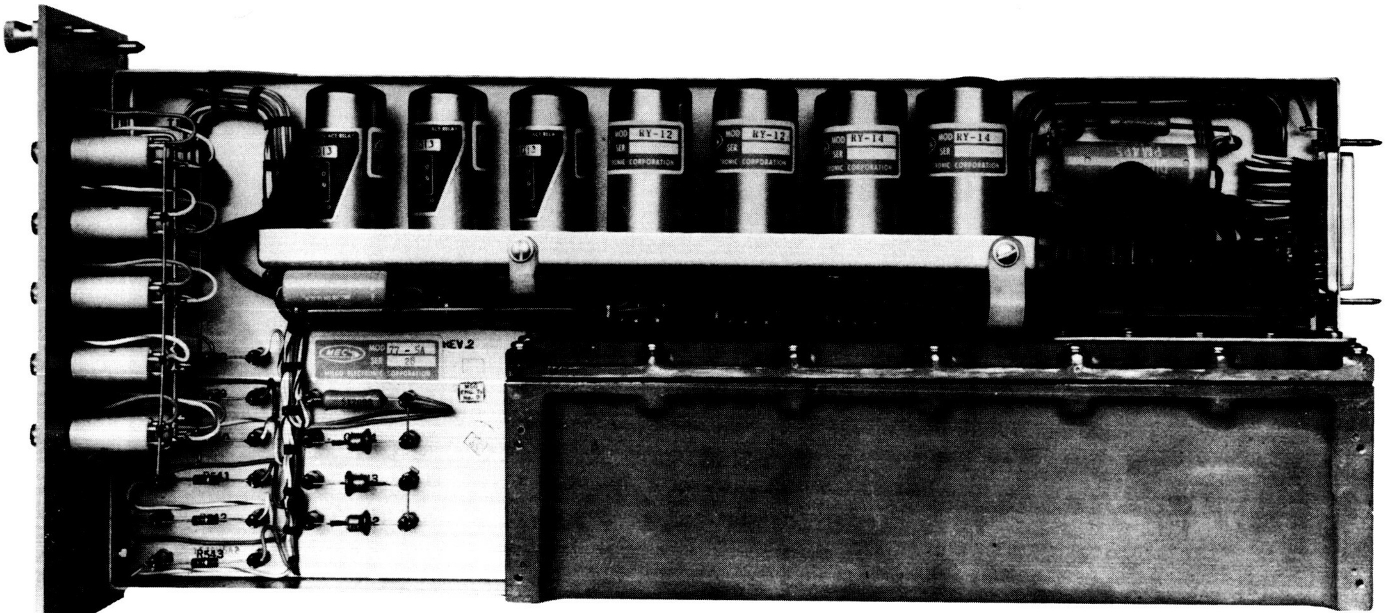


Figure 3-4. Side View, Data Summing Chassis

made through a silicon rubber connector in the upper section of the container. The casting may be opened for servicing, if necessary. Should any difficulty with the networks arise, other than that portion associated with the feedback of amplifier B, the units should be returned to the manufacturer for repair. DO NOT ATTEMPT FIELD REPAIRS. Eleven mercury-wetted relays, K501 through K511 are located on a bracket directly above the oil filled container. Polarized mercury-wetted relays have been utilized to insure long contact life and to minimize operation and release times. On the front panel of the Data Summing Chassis are 10 indicator lamps which are labeled in accordance with the binary weight they represent in the circuit, that is, between 1 and 512. Since all relays in this unit operate in a similar manner, the following discussion will be concerned only with relay K511 and its associated circuitry.

3-4.2 Detailed Theory - If a "1", or 0 volts significant data level is received at terminal 17 of connector P501, current flows from the data input through resistor R546 and through the coil of relay K501 from pin 8 to pin 7 to the -20 volt bus. This current energizes relay K511 placing resistor R511 in the feedback loop of DC amplifier A. Resistors R502 through R510 are shorted out by the wipers of relays K502 through K510. When the input level returns from 0 volts to -20 volts, terminal 8 is pulled down toward -70 volts by resistor R525, thus giving the reverse bias on resistor R546 and the current is caused to flow from the -20 volt supply through the coil of relay K511 and resistor R525 in the opposite direction than before. The drop out time of the relay is greatly reduced by forcing current back through the relay coil as the relay is being de-energized. Indicators DS501 through DS510 employ individual neon lamps. These lamps will light when the input to terminal A is at 0 volts which gives a total of 70 volts across the neon and its associated resistor R535. When terminal A of the indicator lamp is returned to -20 volts, there is only 50 volts across the lamp and its resistor. This 50 volts is insufficient to keep the lamp conducting, therefore it will go out.

3-4.3 A complete description of the utilization of the binary weighted resistors and their relationship to the DC Amplifier was discussed in paragraph 3-3 "D-A Conversion". All other relay inputs to the Data Summing Chassis operate in exactly the same manner as the one previously discussed.

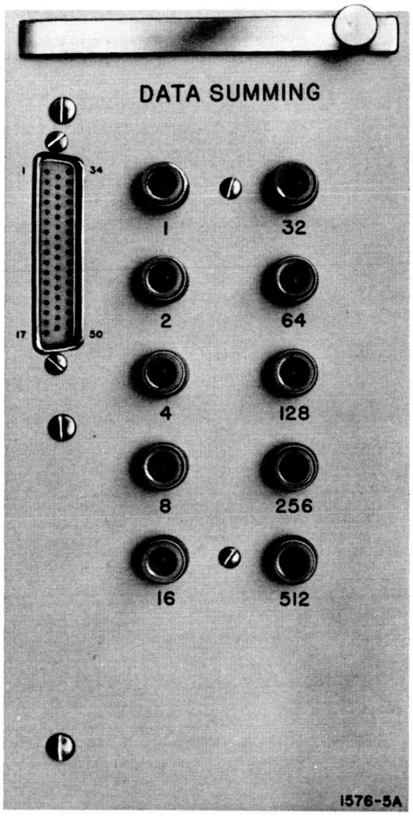


Figure 3-5. Data Summing Chassis

3-5. 20 BIT SHIFT REGISTER, MEC MODEL 1576-7A (Figures 9-5 and 9-6)

3-5.1. General - The function of the 20 Bit Shift Register is to accumulate data in serial form and transfer it into a parallel form. The data is received serially and stored in 20 magnetic cores (M701 through M720). Upon command, the data is read into 20 flip-flops N701 through N720 and will remain there while new data is being shifted through cores M701-M720.

3-5.2. Detail Theory - In the Control Chassis two pulses are derived; a "reset trigger" (from -20 volts to 0 volts, width 4 microsecond) and a "data gate trigger" (from -20 volts to 0 volts, width 4 microsecond). The flip-flop "reset trigger" is capacity coupled through C701 to pin 3 of one-shot N723, with emitter follower output. When pin 3 of N723 goes positive (from -20 volts to 0 volts) the output pin 7 goes positive (from -20 volts to 0 volts, width approximately 5 microsecond). Pin 7 of N723 is capacity coupled through C702 to pin 6 of all the flip-flops (N701 through N720). Pin 6 of N701 through N720 is biased at -10 volts by resistors R721 and R722. Therefore, as pin 7 of N723 goes positive (from -20 volts to 0 volts), pin 6 of all the flip-flops goes positive (from -10 volts to about + 7 volts), resetting all the flip-flops to the "0" state. The states of the flip-flops (TN28) are defined as (a) when pin 8 is at 0 volts the flip-flop is in a "1" state, and conversely (b) when pin 8 is a -20 volts the flip-flop is in a "0" state. At the same time that the flip-flop "reset trigger" enters the shift register a "data gate trigger" (from -20 volts to 0 volts, width 4 microsecond) triggers pin 3 of one-shot N722. The pin 7 output of N722 goes to pin 5 of all cores M701 through M720, and is called the flip-flop-gate. When pin 3 of N722 is triggered, the output provides a gate pulse (-20

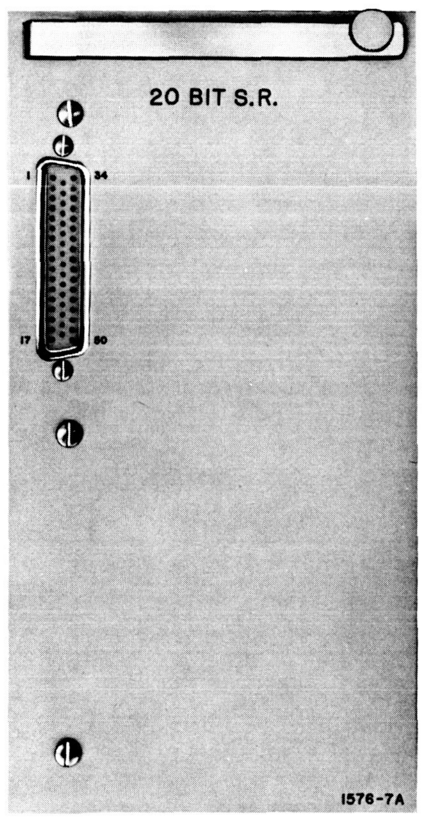


Figure 3-6. 20 Bit Shift Register

volts to 0 volts, width 50 microseconds) and pin 5 of all cores goes positive from -20 volts to -2 volts, for 50 microseconds. R703 and R708 are used to give a -2 volt noise bias when the gate is open. Since the gate raises pin 5 of M701 through M720, subsequently pin 4 of M701 through M720 rises to -2 volts, but the flip-flops will not trigger. A voltage equal to or greater than 0 volts must be present at pin 3 of the flip-flops in order for a change of state to occur. The next shift pulse will cause the states of the cores to be read out into the flip-flops. This shift pulse will be during the flip-flop gate and will cause the readout from the core to transfer their data to the flip-flops. Assuming that there was a "1" in the core, a 10 microsecond pulse, of 5 to 8 volts in amplitude will be super-imposed on the flip-flop gate at pin 4 of the cores, causing pin 3 of the flip-flop to go positive enough to change the state of the flip-flop to a "1". If there was a "0" in the core, only the flip-flop gate will be present at pin 4 of the core; consequently pin 3 of the flip-flop will go positive to only -2 volts, which is insufficient to change the state of the flip-flop. Since the flip-flop is initially reset to the "0" state, and this state remains unchanged if the core is in the "0" state, effectively one may say that the data in the core has been transferred to the flip-flops. The states of the cores are determined by the data which is read in serially. The serial data read in and the core shift pulses occur at the same time and their repetition rate can be up to 4000 per second. Pin 8 of M701 is the data input. Pin 9 of M701 is directly coupled to pin 8 of M702 and pin 9 of M702 is directly coupled to pin 8 of M703. This is repeated from M703 through M720 and constitutes a serial read in arrangement. Since all pin 5's of the cores are connected together and the flip-flop gate occurs at all cores simultaneously, the data is read out on pin 4 of the cores to pin 3 of the flip-flops, in parallel. Operation of the core string is explained in detail in the Appendix in "Magnetic Cores" section. N721 is a core driver operating with a blocking oscillator core (M721). The data in the flip-flops is read out continuously except for data transfer time. This is the time between reset and when the new data is read out of the cores. Each flip-flop N701 through N720 has an output connected to pin 8 of the network. C704 and C705 are used as filter capacitors between the power input voltages. Diode CR701 and resistors R704 and R705 make up a noise bias input circuit. CR703, R706 and R707 are also used for noise bias. R701 and R702 form the -10 volts for bias of the off sides of the flip-flops.

3-5.3. The 20 Bit Shift Register has a building capacity, in that a number of them can be connected in series to facilitate any number of bits in a word.

3-6. CHOPPER DRIVE CHASSIS, MEC MODEL 77-9A (Figures 9-7 and 9-8)

3-6.1. The Chopper Drive Chassis, Model 77-9A contains the necessary circuitry to drive the DC Amplifier choppers. This circuitry primarily consists of a plug-in transistor network TN134 and four transistors, Q1, Q2, Q3 and Q4 and their associated coupling circuits. On the front panel of the chassis are three test jacks which are labeled as shown on figure 3-7. A detail theory of operation of the TN134 is given in the APPENDIX under the heading "TN134 Gated Oscillator and Squaring Circuit."

3-6.2. The TN134 operates as a Colpitts oscillator which is resonated by split capacitors C1 and C2, in parallel with an inductor L1. This circuit is tuned to 94 cycles and can be adjusted by the variable inductor L1. The square wave output of pin 8 of the TN134 is applied through resistor R1 to transistor Q1. The collector output of Q1 is brought out to test jack TJ2 for monitoring purposes and is also applied to the base of Q2 which is used as a pulse amplifier. The output of Q2 is applied to the power output circuit consisting of Q3 and Q4. The emitter output of Q4 is coupled via C3 to the Chopper Drive output which will drive the chopper coils in the DC Amplifiers. Test Jack TJ3 is for monitoring the output of this circuit.

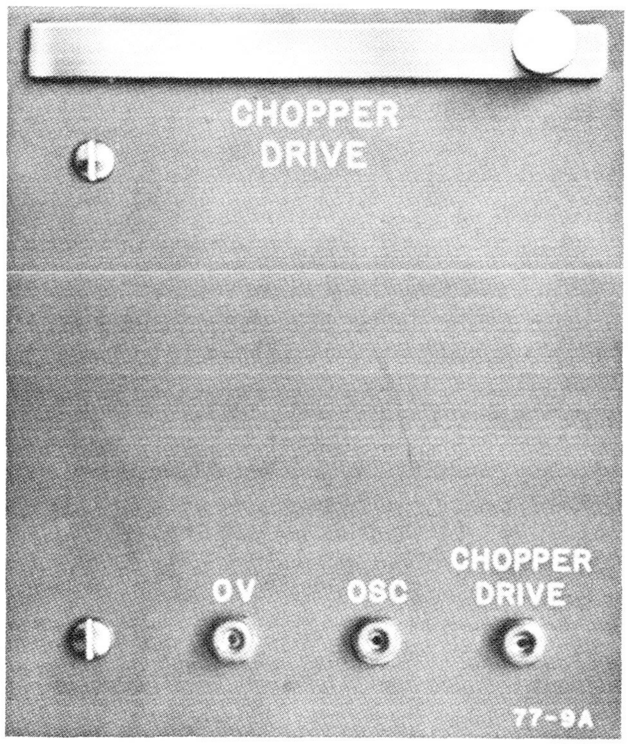


Figure 3-7. Chopper Drive Chassis

3-7. DC AMPLIFIER CHASSIS, MEC MODEL 63-4C (Figures 9-9, 9-10 and 9-11)

3-7.1. The DC Amplifier Chassis is a dual package containing two identical direct coupled DC amplifiers. Each DC amplifier contains a separate stabilizer portion to insure low DC drift. For correct operation, the DC amplifier unit must be supplied with the following d-c and a-c signals:

a. +250v*
b. -250v*
c. -560v (.88 milliamperes)
d. 12.6 vac at -125v reference (1.05 amperes)
e. 12.6v at ground (.6 amperes)

All amplifier computing networks must be supplied externally to the amplifiers. These computing networks are usually located in sealed containers in other elements of the overall equipment rack. Before proceeding with a detailed explanation of the DC Amplifier Chassis, a general theory of DC amplifier operation will be briefly covered to illustrate various computing circuit logic as well as the method of stabilization against drift.

3-7.2. Figure 3-9 illustrates the amplifier connected as a summing amplifier. Assuming that the gain of the amplifier ($-\mu$) is very large (approaching infinity), it follows that the input voltage "e" $e = -\frac{E_o}{\mu}$ approaches 0 and the following equation may be written:

$$I_1 + I_2 = I_o$$

$$\text{Where } I_1 = \frac{E_1 - e}{R_1} \quad \text{or} \quad \frac{E_1}{R_1} \quad \text{since } e = 0 \qquad (1)$$

$$I_2 = \frac{E_2 - e}{R_2} \quad \text{or} \quad \frac{E_2}{R_2}$$

$$I_o = \frac{-E_o - e}{R_o} \quad \text{or} \quad \frac{-E_o}{R_o}$$

$$\frac{E_1}{R_1} + \frac{E_2}{R_2} = \frac{-E_o}{R_o} \qquad (2)$$

$$E_o = \frac{-R_o}{R_1} E_1 \quad \frac{-R_o}{R_2} E_2 \qquad (3)$$

$$E_o = -K_1 E_1 \quad -K_2 E_2 \qquad (4)$$

Where

$$K_1 = \frac{R_o}{R_1} \quad \text{and } K_2 = \frac{R_o}{R_2}$$

*Current drawn from the +250 and -250 volt Supplies depends upon the load into which amplifier is to be operated. The nominal value is 12.25 milliamperes.

Equation (4) indicates that the DC amplifier output voltage is proportional to the sum of the input voltages multiplied by their respective network constants. This is true for any reasonable number of inputs.

3-7.3. Figure 3-10 shows the amplifier connected as an integrating amplifier. Considering "e" to be 0 (see preceding derivation) the following relationships will be found to exist:

$$I_1 = \frac{E_1}{R_1} \tag{1}$$

$$I_2 = \frac{E_2}{R_2} \tag{2}$$

$$I_o = -C\frac{dE_o}{dt} \tag{3}$$

Since

$$I_1 + I_2 = I_o \tag{4}$$

$$\frac{E_1}{R_1} + \frac{E_2}{R_2} = -C\frac{dE_o}{dt} \tag{5}$$

$$-CE_o = \int_o^t \frac{E_1}{R_1}\,dt + \int_o^t \frac{E_2}{R_2}\,dt \tag{6}$$

$$E_o = -\frac{1}{R_1 C}\int_o^t E_1\,dt + \int_o^t E_2\,dt \tag{7}$$

$$E_o = -K_1\int_o^t E_1\,dt - K_2\int_o^t E_2\,dt \tag{8}$$

Where

$$K_1 = \frac{1}{R_1 C} \qquad K_2 = \frac{1}{R_2 C}$$

Equation (8) indicates that the output voltage of an amplifier connected as illustrated in figure 3-10 consists of the sum of the integrals of the various input voltages divided by their respective network constants.

3-7.4. Figure 3-11 shows the amplifier connected as a differentiating amplifier. Considering "e" to be 0 (see first derivation), the following relationships will be found to exist:

$$I_1 = -C\frac{dE_1}{dt} \tag{1}$$

$$I_o = \frac{E_o}{R_o} \tag{2}$$

Since

$$I_1 = I_o \tag{3}$$

$$-C_1 \frac{dE_1}{dt} = \frac{E_o}{R_o} \tag{4}$$

$$E_o = -R_o C_1 \frac{dE_1}{dt} \tag{5}$$

$$E_o = -K_1 \frac{dE_1}{dt} \tag{6}$$

Where

$$K_1 = -R_o C_1$$

The output of the differentiating amplifier, illustrated in figure 3-11, is the first derivative (rate of change) of the input voltage, multiplied by a constant determined by the network.

3-7.5. Figure 3-12 shows the method by which drift stabilization is accomplished. Offset voltage "e_d" is defined as the voltage required at the input terminal of the amplifier to make its output equal zero. Offset is generally due to three main causes.

a. Drift of elements within the amplifier.
b. Grid current at the input terminal.
c. Improper grounding.

Precautions have been taken during manufacture to eliminate the latter two causes while a stabilizer of the type shown in figure 3-12 is added to reduce the effects of the first cause.

e_d = drift referred to input (voltage that would be required at input to make output zero)

$-\mu_1$ = gain of DC portion

μ_2 = gain of DC portion associated with stabilizer

$-\mu_3$ = DC gain of stabilizer amplifier

$$E_o = -\mu_1 e_1 + \mu_2 e_2$$

$$e_j = \frac{R_1}{R_1 + R_o} E_o$$

$$e_1 = e_j - e_d = \frac{R_1}{R_1 + R_o} (E_o - e_d)$$

$$e_2 = -\mu_3 e_j = -\mu_3 \left(\frac{R_1}{R_1 + R_o}\right) E_o$$

$$E_o = -\mu_1 \left(\frac{R_1}{R_1 + R_o}\right) E_o + \mu_1 e_d - \mu_2 \mu_3 \left(\frac{R_1}{R_1 + R_o}\right) E_o$$

$$E_o = \frac{\mu_1 e_d}{1 + (\mu_1 + \mu_2 \mu_3)\left(\frac{R_1}{R_1 + R_o}\right)}$$

since $(\mu_1 + \mu_2\mu_3) >> 1$

$$E_o = \frac{\mu_1}{\mu_1 + \mu_2 \mu_3} \left(\frac{R_1 + R_o}{R_1}\right) e_d$$

If there were no stabilizer then $\mu_3 = 0$ and

$$E_o = \left(\frac{R_1 + R_o}{R_1}\right) e_d$$

Therefore the stabilizer reduces drift by the factor $\dfrac{\mu_1}{\mu_1 + \mu_2\mu_3}$

Assuming μ_1 and μ_2 almost equal and $\mu_2\mu_3 >> \mu_1$, drift is reduced by the factor $\dfrac{1}{\mu_3}$ or by a factor proportional to the DC gain of the stabilizer. It should be noted that when the stabilizer is added to an amplifier there are two DC paths between the input and output of the amplifier; one via the normal DC coupled section, and the other through the stabilizer and that portion of the DC coupled section associated with the stabilizer portion from the summing juncture. A capacitor is placed between this input stage grid and the summing juncture. The normally DC coupled section in essence then becomes capable of passing frequencies only above a minimum frequency as determined by the time constant of the input circuitry; hence this portion is no longer direct coupled. The time constant of this input circuit is so apportioned that those frequencies blocked (low frequencies down to dc) are ones capable of being passed by the stabilizer portion. In this way the amplifier is capable of operating over the full frequency range and down to dc.

3-7.6. Two indicator lamps, two screwdriver-adjustable potentiometers, two pushbutton switches, and two test jacks are located on the front panel. One lamp, potentiometer, pushbutton switch, and test jack appear on the left portion of the panel and are denoted by a letter designation A, while the other indicator, potentiometer, pushbutton, and test jack appear on the right portion of the front panel, and are denoted by a letter designation B. These controls, indicators, and test jacks are associated with the two amplifiers located within the chassis; the A amplifier being located in front and the B, in the rear.

a. The output terminal of each amplifier has been brought out to the small test jacks to enable the operator to place a cope, meter or other instrument on the output of each amplifier for any test purposes desired.

b. The potentiometers allow for balancing the DC amplifiers. To balance a given DC amplifier, depress the pushbutton immediately below the balance potentiometer and adjust the potentiometer so that the neon indicator located directly above it is extinguished. Once the adjust ment has been made, the pushbutton is released and the amplifier is balanced.

c. With the pushbutton released the neon indicator acts as an overload indicator for the amplifier. Whenever the amplifier reaches the end of its operational range the overload indicator will glow indicating that the computation is no longer correct. Overload condition is usually caused by exceeding the output capabilities of the amplifier either because of excessive output voltage or excessive load.

3-7.7. Figures 9-9, 9-10 and 9-11 are schematic and wiring diagrams of the DC amplifier. Note that in figure 9-9 there appear two identical DC amplifiers. The amplifier located in the upper part of the schematic is amplifier A; that in the lower portion, amplifier B. Since A and B amplifier sections are identical, only the A section is described.

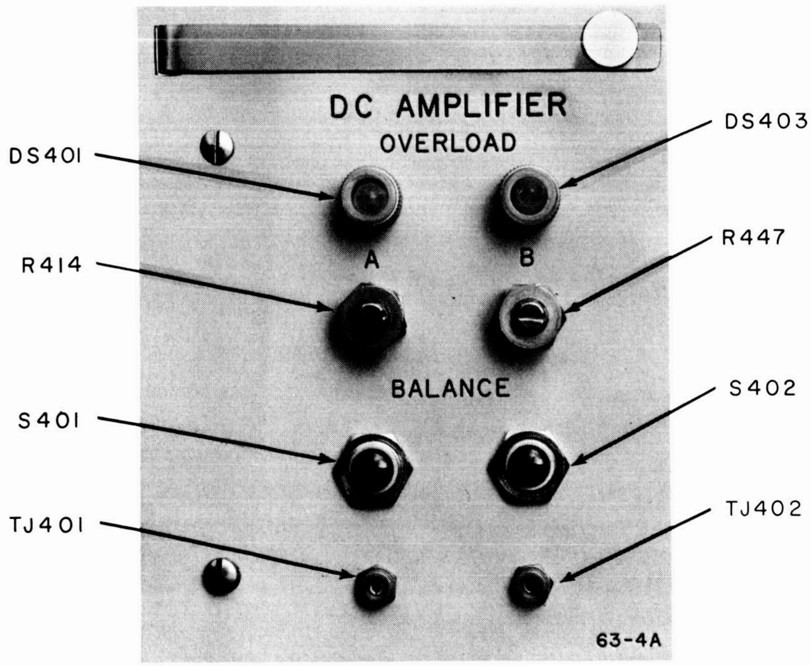


Figure 3-8. DC Amplifier Chassis

3-7.8. Amplifier A is composed of a direct-coupled amplifier and a drift compensating section. The DC, or direct coupled section, is comprised of tubes V401, V402, and V403, and associated components. The drift stabilizer portion is represented by converter K401A and tube V404, along with associated components. The junction of the external input and feedback network elements is coupled to terminal 1 through a coax cable within the rack. Terminal 1 is the input to amplifier A and is normally referred to as the summing junction. The input (error signal) from the summing junction is coupled via capacitor C402, resistor R404 and diodes CR403 and CR404 to the input grid (terminal 7) of input stage V401. Unless diode CR403 or diode CR404 is conducting, direct coupling between the input terminal 1 and the grid of the first amplifier tube is lost due to the coupling condenser C402. In actual operation both the amplifier grid (due to R404) and the summing junction (due to the action provided by the stabilizer loop) are operating at very near ground potential; therefore, diodes CR403 and CR404 are operating in a non-conducting region. Under these conditions condenser C402 blocks grid current that may be generated by tube V401 from the summing juncture, the grid current leading to ground through the path provided by resistor R404. Diodes CR403 and CR404 are placed in parallel with C402 in order that the voltage across C402 can be limited to within the operational range of the input grid of tube V401 during overload conditions of the DC amplifier, thus rapid recovery upon discontinuance of the overload condition is assured. The DC path required for operation of the amplifier is now obtained through the stabilizer portion and reinserted into the right-hand section of tube V401. This right-hand section is cathode coupled into the first section that is in turn directly coupled throughout the remaining DC portion to the output terminal of the amplifier. The amplified output signal appearing on the plate (pin 6) of input tube V401 is directly coupled by means of resistors R416, R415 and balance potentiometer R414 to the input grid of pentode amplifier tube V402. Under normal operational conditions the plate (pin 6) of V401 is operating at approximately +60 volts with respect to ground. The divider network, consisting of resistors R416, R414 and R415, is connected between this +60 volt plate voltage and the -560 volt bias voltage to provide approximately -254 volts on the grid (terminal 1) of tube V402. Since the cathode of tube V402 is tied directly to the -250 volt Supply, a bias of approximately -4 volts results. The screen (pin 6) of amplifier tube V402 is stabilized by means of cold cathode neon lamp DS401, to approximately 65 volts above the cathode voltage (-250 volts). The plate (pin 5) of tube V402 is returned through resistor R418 to the +250 volt Supply. The output of tube V402 is therefore able to swing between a voltage near +200 to a voltage near -200 depending upon the input signal. The output of pentode amplifier V402 is coupled to pin 2 of output tube V403B by means of a voltage divider consisting of resistors R423 and R427. Since the plate of pentode amplifier V402 operates approximately 125 volts positive with respect to its cathode (-250 volts), the plate is at approximately -125 volts with respect to ground. This negative 125 volts when coupled through divider R423 and R427, causes the grids of the output stage V403B (terminal 2) to assume approximately -266 volts; i.e., a grid bias of approximately -16 volts exists.

3-7.9. The elements in output tubes V403A and V403B are connected in what is generally called a Peterson amplifier circuit. This circuit operates as follows: tubes V403A and V403B and resistors R429 and R430 are connected in series across the +250 volt and -250 volt Supplies. The grid of V403A is biased by the drop across resistor R429, the value of R429 being chosen such that maximum output load conditions will be met. As the grid of V403B is made more positive, the plate of V403B will be moved below ground potential causing increased current to flow between the +250 volt and -250 volt Supply. This increased current increases the IR drop across resistor R429 resulting in increased bias on tube V403A, and therefore, in a net increase in the plate resistance of this tube. If a load is connected to the output circuit, it can be seen that the biasing of V403A will be even more rapid for a given bias change on V403B due to increased drop across R429. As a result, for a negative going output excursion the current drawn from the +250 volt Supply will decrease as the output increases negatively. Conversely, if the bias on tube V403B is made more negative the plate voltage of V403B tends to rise, reducing the current flow through resistor R429, thereby decreasing the bias on tube V403A. This in turn causes V403A to furnish the necessary current to produce the positive output excursion. Resistor R430 acts as a limiting resistor for positive excursions of amplifier output. This resistor is necessary in order that the plate dissipation of tube V403A not be exceeded under certain load conditions.

3-7.10. The overall gain of the DC portion of the amplifier is approximately 40,000. During applications the amplifier may be called upon to operate at various gains between zero to 100 or more. It is necessary that proper roll-off networks be placed in the amplifier to prevent instability under conditions of large changes of feedback ratios. The particular roll-off networks utilized in the amplifier will depend upon application. These networks consist of capacitors C406, C410, C423, C425 and C427 and resistors R417, R424 and R428. In the amplifier proper, most of these networks are mounted by means of screw type tie points; therefore, it is possible to change these networks without soldering. In any given amplifier it is unlikely that all of the resistors and capacitors will be utilized at one time for cutoff purposes.

3-7.11. A mathematical derivation covering the operation of the stabilizer circuit was presented in paragraph 3-7.5. The stabilizer circuit operates by sampling the error voltage (e) appearing on the summing juncture, amplifying, then reinserting this amplified signal into the DC portion of the amplifier in such a manner as to cause a reduction in the original offset error. Referring to figure 9-9 (schematic), the summing juncture error voltage is coupled to the input of the chopper circuit by means of resistors R403, R401 and R402. A mechanical (or electronic) chopper, K401A, alternately shorts and opens, causing a square wave proportional to the magnitude of the error voltage to be applied to the grid of a-c amplifier tube V404A. The a-c signals applied to the grid of amplifier tube V404A are amplified and coupled by capacitor C405 to the input of amplifier stage V404B. Here again the signals are amplified and coupled by capacitor C409 and resistor R432 to a second set of contacts in converter K401A. This second set of contacts is used to rectify the a-c signal from the output of tube V404B to restore the d-c component to the signal. The rectified signal is coupled via an RC filter, consisting of resistor R433 and capacitor C411, to the input grid of the right-hand portion of input stage V401. As previously described, this stage is used to cathode couple the amplified stabilizer error voltage signal to the first amplifier tube in the DC portion of the amplifier. This signal in turn modifies the output of the DC amplifier so as to reduce the error voltage occurring at the summing juncture.

3-7.12. Resistor R403 and diodes CR401 and CR402 act as a voltage-limiting device to the input of the stabilizer portion of the amplifier. When the rise time characteristics of the input signal to the overall DC amplifier exceed the frequency capabilities of the amplifier (as determined by the roll-off networks) a transient will appear at the summing juncture. Resistor R403 in conjunction with diodes CR401 and CR402 limit this transient before application of the summing juncture error signal to the stabilizer input filter consisting of resistors R401 and R402, and capacitor C401. This latter filter in turn reduces the magnitude of such impulses before application to the input of the first amplifier tube V404A. DC Amplifier 63-4A may therefore be utilized for pulse type as well as d-c type signal inputs. A polystyrene condenser C403 is connected between the output of filter R401, R402, C401 and the grid of the first amplifier stage V404A, thereby effectively blocking any grid current generated by tube V404A from the summing juncture. The grids of a-c amplifier tubes V404A and V404B are operated at fixed bias of approximately -1 volt, developed by means of resistor dividers R425 and R408. Tube V404A amplifies the chopped signal appearing at the junction of converter K401A and capacitor C403. This amplified signal has a portion of the higher frequency components removed by a roll-off network consisting of resistor R413 and capacitor C404 before application to the second amplifier stage V404B. A second roll-off network consisting of resistor R420, R421 and capacitor C408 is associated with this second stage to further remove high frequency components.

3-7. 13. The amplified signal from tube V404B is capacity coupled via **capacitor** C409 to a second (rectifying) portion of converter K401A. This resultant rectified **signal** is applied to an RC filter consisting of resistor R433, capacitor C411, and diode CR406. Positive output excursions appearing on the filter (i. e., on the input of tube V401) are limited by conduction of the grid (pin 2) of tube V401 through the cathode and diode CR405 to divider network R410, R411 and R412. Diode CR406 limits the negative excursion appearing on the output of the filter (i. e., on the grid of V401). Neon overload indicator DS402 is connected across the output of amplifier tube V404B. When an overload occurs, the summing juncture no longer remains at ground potential and a relatively large signal is coupled to the input of the stabilizer circuit. This signal is amplified by tubes V404A and V404B, producing a large output signal at pin 6 of tube V404B, thereby energizing neon overload indicator DS402.

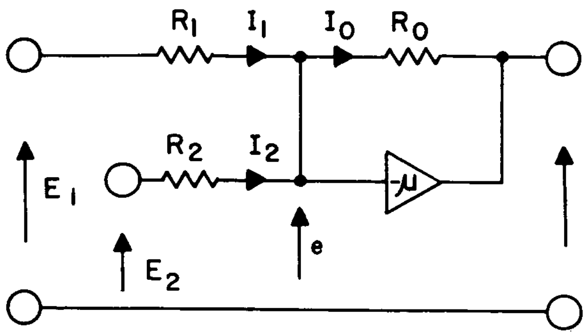
3-7. 14. Balancing of the DC amplifier is accomplished by utilizing the stabilizer amplifier as a means for determining whether or not any offset voltage exists on the input terminal (summing juncture) of the DC amplifier. During this measurement the stabilizing correction signal must be removed from the DC portion of the amplifier and condenser C402 must be shorted. Balancing is accomplished as follows: depress BALANCE push-button S401 to remove stabilizer correction signal from pin 2 of tube V401 by shorting condenser C411 to ground. In addition, contacts 1A and 1B of switch S401 short condenser C402. If balance control R414 is now rotated, the offset signal appearing at the summing juncture may be negative, zero or positive. If the signal is at or near zero, balance indicator DS401 will be extinguished. If the balance control is moved to either side of the balance position, the neon indicator will glow. When the balance potentiometer has been adjusted so as to cause the indicator to extinguish, the offset signal at the input of the amplifier will be less than 10 millivolts. Upon the release of the BALANCE pushbutton, stabilization is reinserted in the amplifier circuit (tube V401B) and the offset will decrease to less than 50 microvolts.

3-7.15. As the amplifier stands it is capable of driving a 4, 000 ohm load to ±100 volts or a 10, 000 ohm load to ±140 volts. If the amplifier is to drive lower loads, external resistor R_x should be added in accordance with the table shown in the lower portion of figure 9-9. These resistors should not be added unless the load is actually to be driven, as this not only increases the current drain from the Power Supply, but in some instances can result in over-dissipation within the output tube over certain portions of the output range.

3-7. 16. Nearly all amplifier troubles manifest themselves in three forms:

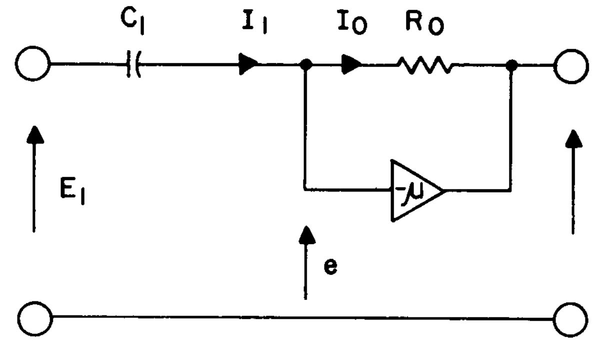
a. Inoperation due to a tube failure. *
b. Inoperation due to a bad mechanical converter K401. *
c. Noise in the output due to a faulty tube. *
d. In the cases where solid state converters are utilized in place of mechanical converters, occasionally one of the incandescent lamps will fail. This should be replaced only with a type 49 lamp.
e. A Mechanical Converter Test Set, Milgo Type 63-4AX should be used should realignment become necessary. This Test Set is shown shown schematically in figure 9-2.

*The corrective action is to replace the bad element.



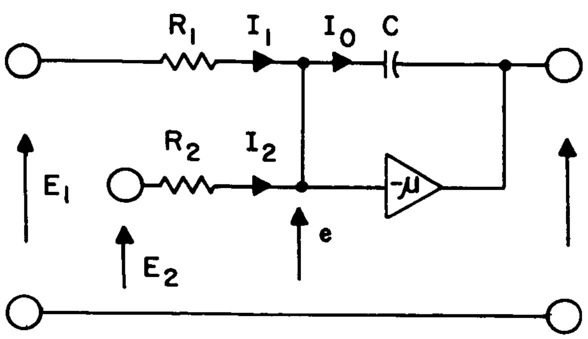
$$E_0 = -\left[\frac{R_0}{R_1}E_1 + \frac{R_0}{R_2}E_2\right]$$

Figure 3-9. Summing Amplifier



$$E_0 = -R_0C\frac{dE_1}{dt}$$

Figure 3-11. Differentiating Amplifier



$$E_0 = -\left[\frac{1}{R_1C}\int_0^t E_1\,dt + \frac{1}{R_2C}\int_0^t E_2\,dt\right]$$

Figure 3-10. Integrating Amplifier

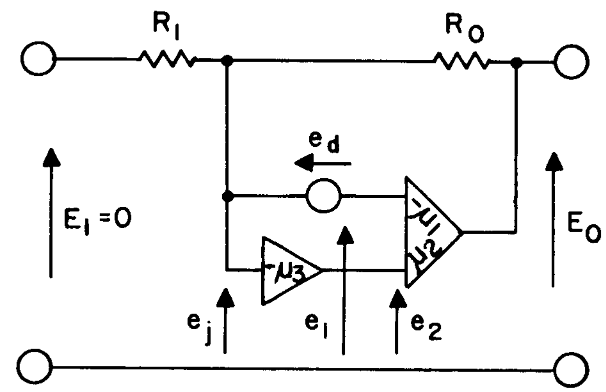


Figure 3-12. Drift Stabilization

CHAPTER IV

OPERATION

With all rack connectors properly connected and the a-c input power supplied to the D-A Converter the following steps are required for operation.

a. Place the a-c power switch located at the lower rear of rack to the ON position. The red indication lamp will glow. Place the STAND-BY switch located on the front panel of the Control Chassis to the ON position. The amber filament indicators located on the high voltage supplies 1576-4A and 1576-3A will light and the Blower should operate. CAUTION: If the Blower is not operating, check in the rear of the rack to make sure that the power switch located on the Blower itself is in the high position. The Blower should be operating before any other steps are considered.

b. Allow at least one minute for the filaments of the vacuum tubes to heat up before turning on the POWER switch to the ON position. When the POWER switch is turned to the ON position, red plate indicator lights on the high voltage Power Supplies will glow.

c. Check the output voltages of all the power supplies utilizing the meter located on the Control Chassis and by operating the VOLTAGE SELECTOR switch, rotate it to each position and observe the meter which is indicating the voltage of the power supplies in each position. The meter should indicate a reading of 10 on each position, and the power supplies should be within this reading by $\pm$ 2%. For a more accurate adjustment of each power supply, an accurate voltmeter may be used to adjust the operation voltages.

d. Balance all DC Amplifiers in the DC Amplifier Chassis; balance the A amplifier first and then the B amplifier. This is accomplished as follows.

   (1) Depress pushbutton S401.
   (2) Rotate potentiometer R414 until the neon indicator DS401 is extinguished.
   (3) Release pushbutton.
   (4) Repeat for S402, R447 and DS403 for the B amplifier.
   (5) Repeat the above procedure for each of the five dual D.C. Amplifiers.

e. Switch the INTERNAL-EXTERNAL reference switch to the desired position. If an external reference voltage is being utilized, operate switch to the EXTERNAL position. If there is no external reference voltage for use, switch to the INTERNAL position. Rotate the VOLTAGE SELECTOR switch to the +REF position and to the -REF position and see if the meter is reading 10. The reading should be very close to the 10 reading. If ±reference voltage reading is desired to be read accurately an external accurate voltmeter should be used to test these voltages which are available on the test jacks found on the front of the reference DC Amplifier, which is the one in the lower right hand corner of the fifth row of chassis. When using an external meter, which is accurate, the reference voltages should be exactly + 35.0 volts and -35.0 volts. Rotate the TEST SELECTOR switch to pattern #1. Watch the indicators as found on the Data Summing Chassis. All lamps should be extinguished. Rotate to pattern #2. Alternate lamps should be on. Rotate the switch to pattern #3. The lamps which were previously on should be extinguished and the ones which were off should now turn on. Rotate the TEST SELECTOR to pattern #4. All lamps should now be on. If there is no malfunction within the D-A Converter it is now considered to be in operation. Rotate the TEST SELECTOR switch to the OPERATE position which is the first position from the left. The system is now in an OPERATE mode.

CHAPTER V
INSTALLATION

5-1. GENERAL

No special considerations are necessary in selecting a site for the D-A Converter. This unit is completely self-contained and the rack provides adequate shielding for operation under normal operation environments.

5-2. INPUT AND OUTPUT CONNECTIONS

External connections to the D-A Converter are made to three different MS type connectors. Table 5-1, 5-2 and 5-3 list each connector and its associated cable information. It should be noted that during installation the a-c power cable and the digital input cable should be isolated from the analog output and reference voltage cables. They may occupy the same cable trough but must not under any circumstances be harnessed or tied together into the same cables.

5-3. INITIAL ADJUSTMENTS

There are no initial adjustments required prior to operation of the equipment. However, it is strongly urged that the Theory of Operation and the Operation sections be read and completely understood before trying to operate the equipment.

TABLE 5-1. ANALOG CONNECTOR J18

Terminal	Identification	AWG
A	Y_1 Analog Output	RG62U
B		
C		
D	-Ref. (-35 volts)	
E		
F		
G	H. Q. Gnd.	#14 or
H		larger
J		for long
K	Ref. (35 volts)	runs.
L		
M		
N	X_1 Analog Output	RG62U
P		
R	Y_2 Analog Output	RG62U
S		
T		
U		
V		
W		
X	X_2 Analog Output	
Y		
Z	Ext. Ref. Input (35 volts)	RG62U

TABLE 5-2. POWER INPUT J19

Terminal	Identification	AWG
A	120 vac ϕ1	#12
B	120 vac Ground	#12
C	Frame Ground	#12
D		
E	120 vac ϕ2	#12

TABLE 5-3. DIGITAL INPUT J20

Terminal	Identification	AWG
A	Data Input	RG62U
B	"Sample" Input	RG62U
C		
D		
E	Signal Ground	#14
F		
G		
H	"Select and Ready" Input	RG62U
J	"D/A Ready" Output	RG62U

CHAPTER VI
MAINTENANCE

6-1 GENERAL

Since a large portion of the circuitry within this D-A Converter except for DC Amplifiers is made up largely of transistor circuits and magnetic cores, it is not expected that malfunction will occur for long periods of operation time. However, malfunction of individual parts are expected and can be located by normal trouble shooting operation. The necessary test equipment for normal maintenance of the D-A Converter is a Mechanical Converter Test set, MEC Type 63-4AX, an oscilloscope and an accurate VOM meter. Many of the malfunctions can be located by observing the neon lamps located on the front panel of the various chassis.

6-2 PREVENTATIVE MAINTENANCE

Preventative maintenance is recommended for the following parts of equipment.

a. The blower filter should be removed and cleaned in a solution of warm water and detergent or cleaned with a vacuum cleaner at least once each week.

b. The various electronic tubes should be tested periodically (approximately every 1,000 operating hours.)

c. The adjustments of the voltage control on each of the power supplies should be checked to see if the correct voltage may be adjusted by this control at least once each week.

6-3 ELECTRO-MECHANICAL DEVICES

If any of the relays or other electro-mechanical devices do not function properly, the complete sub assembly should be replaced and the malfunctioning unit may be returned to the manufacturer for possible repairs. Resistor Network RN44 found in the Control Chassis should not be serviced. If it requires repair, it must be returned to the manufacturer for possible repairs. DO NOT attempt field repairs of the sealed resistor network found in the Data Summing Chassis. Return it to the manufacturer for possible repairs if it does not function properly.

CHAPTER VII

PARTS LIST

The MEC Model 1576 D/A Converter consists of the following assemblies:

QUANTITY	ASSEMBLY	PAGE
1	MEC Model 1576-1AA, Rack	7-3
1	MEC Model 77-9A, Chopper Drive	7-4
1	MEC Model 1576-3A, Power Supply	7-5
1	MEC Model 1576-4A, Power Supply	7-7
5	MEC Model 63-4C, DC Amplifier	7-8
4	MEC Model 1576-5A, Data Summing	7-12
2	MEC Model 1576-7A, 20 Bit Shift Register	7-13
1	MEC Model 1576-6A, Control	7-14
1	MEC Model 165-4A, Power Supply	7-19
1	Blower	7-21

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	3 STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
1-1				MEC 1576-1AA	ASSEMBLY, RACK, D-A CONVERTER	1	
1-2				MEC B1007A41AE	ASSEMBLY, STANDARD CONNECTOR PLATE (5-1/4)	6	
1-3				MEC B1007A41AF	ASSEMBLY, STANDARD CONNECTOR PLATE, LEFT HAND, (7")	2	
1-4				MEC B1007A41AH	ASSEMBLY, STANDARD CONNECTOR PLATE, LEFT HAND (8-3/4)	8	
1-5				MEC B1007A41AJ	ASSEMBLY, STANDARD CONNECTOR PLATE, RIGHT HAND (8-3/4)	1	
1-6	DS1, DS2			Eldema 1CG12-4535	LAMP, Neon to spec. 21C-3864-7	2	
1-7	F1, F2			Bussmann FNM	FUSE, 5 amp	2	
1-8	J18			Cannon MS3102-A-32-13P	PLUG, 13 pin contact	1	
				Cannon MS3106B-32-13S	CONNECTOR, 13 pin contact	1	
				Cannon MS3057-20	CABLE CLAMP	1	
1-9	J19			Cannon MS3102A-18-11P	PLUG, 11 pin contact	1	
				Cannon MS3106B-18-11S	CONNECTOR, 11 pin contact	1	
				Cannon MS3057-10	CABLE CLAMP	1	
1-10	J20			Cannon MS3102A-22-17P	PLUG, 17 pin contact	1	
				Cannon MS3106B-22-17S	CONNECTOR, 17 pin contact	1	
				Cannon MS3057-12	CABLE CLAMP	1	
1-11	S1			Carling 2GL63-73	SWITCH DPDT, on-non-on	1	
1-12				Bussmann HPC-C	FUSE HOLDER	2	
1-13				Eldema 11H4593	INDICATOR HOLDER	2	
1-14				Eldema 11H-4119	LENS CAP (Red)	2	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
9-1				MEC 77-9A	ASSEMBLY, CHOPPER DRIVE	1	
9-2	C1			Cornell Dubilier PM4S5	CAPACITOR, Fixed Mylar, .05μf 400 vdc	1	
9-3	C2			Cornell Dubilier PM4P5	CAPACITOR, Fixed Mylar, .5μf 400 vdc	1	
9-4	C3			Mallory 20-71937	CAPACITOR, Computer Grade, 4000μf 50 vdc 2-1/16 x 4-1/2 Alum. can, with Acetate Sleeve.	1	
9-5	L1			U.T.C. HVC-11	INDUCTOR, Type TF4RX20YY	1	
9-6	N1			MEC TN134	TRANSISTOR NETWORK	1	
9-7	P1			Cannon DD-50P	PLUG	1	
9-8	Q1			G. E. 2N525	TRANSISTOR	1	
9-9	Q2-Q4			Delco 2N443	TRANSISTOR, (Lug Type Leads) with Mounting Kit # 7272602	3	
9-10	R1			MIL RC20GF103K	RESISTOR, Fixed composition, 10K ±10% 1/2W	1	
9-11	R2, R5			MIL RC20GF473K	RESISTOR, Fixed composition, 47K ±10% 1/2W	2	
9-12	R3			MIL RC20GF472K	RESISTOR, Fixed composition, 4.7K ±10% 1/2W	1	
9-13	R4			MIL RC20GF102K	RESISTOR, Fixed composition, 1K ±10% 1/2W	1	
9-14	R6			Ward Leonard 10F100	RESISTOR, Fixed, Wire Wound, 100Ω 10W	1	
9-15	R7			MIL RC32GF471K	RESISTOR, Fixed composition, 470Ω ±10% 1W	1	
9-16	R8			MIL RC20GF223K	RESISTOR, Fixed composition, 22K ±10% 1/2W	1	
9-17	R9			Ward Leonard 10F75	RESISTOR, Fixed, Wire Wound, 75Ω 10W	1	
9-18	R10			Ward Leonard 5X5	RESISTOR, Fixed Axiohm, 5Ω 5W	1	
9-19	TB1			USECO 1100-B	TERMINAL BOARD	1	
9-20	TJ1-TJ3			H.H. Smith 1501-113	JACK, Wrap Around	3	
9-21	XN1			JAN TS101P01	SOCKET, Tube Octal, Mica filled	1	
9-22				Birtcher 3B-645	RADIATOR, Power Transistor	3	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	3 STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
3-1				MEC 1576-3A	ASSEMBLY, POWER SUPPLY, -250V, -560V	1	
3-2	C301			Sangamo 7110-2R	CAPACITOR, Fixed, 2μf 1000 vdc	1	
3-3	C302			Aerovox JP616MCB	CAPACITOR, Fixed, 1μf 600 vdc	1	
3-4	C303-C307 C309, C310			Aerovox AEP88J	CAPACITOR, Fixed Dual, 40-40μf 450 vdc Plug-In.	7	
3-5	C308			Cornell Dubilier PM4P47	CAPACITOR, Fixed Mylar, .47μf 400 vdc	1	
3-6	CR301-CR312			G. E. IN1695	DIODE	12	
3-7	DS301 DS302			Eldema 1CG12-4535	LAMP, Neon to Spec. 21C-3864-7	2	
3-8	F301-F302			Bussmann AGC	FUSE, 3 Amp	2	
3-9	F303			Bussmann MDL	FUSE, 1/2 Amp, 250V, Slo-Blo	1	
3-10	L301			Chicago Std. RH-8300	CHOKE, (Filter Reactor) 300 madc, 8 Hy 55Ω dc, Type TF4RX01YY	1	
3-11	L302			Chicago Std. RH-1055	CHOKE, (Filter Reactor) 55 madc, 10 Hy 230Ω dc, Type TF4RX01YY	1	
3-12	P301			Cannon DD-50P	PLUG	1	
3-13	R301-R304			MIL RC20GF474K	RESISTOR, Fixed composition, 470K ±10% 1/2W	4	
3-14	R305, R306			Ward Leonard 5X2, 000	RESISTOR, Fixed Axiohm, 2K 5W	2	
3-15	R307-R309			MIL RC20GF101K	RESISTOR, Fixed composition, 100Ω ±10% 1/2W	3	
3-16	R310, R312 R314			MIL RC42GF470K	RESISTOR, Fixed composition, 47Ω ±10% 2W	3	
3-17	R311, R313 R315, R316 R318			MIL RC20GF102K	RESISTOR, Fixed composition, 1000Ω ±10% 1/2W	5	
3-18	R317, R322			MIL RC42GF823K	RESISTOR, Fixed composition, 82K ±10% 2W	2	
3-19	R319, R323			MIL RC20GF824K	RESISTOR, Fixed composition, 820K ±10% 1/2W	2	
3-20	R320			MIL RC20GF334K	RESISTOR, Fixed composition, 330K ±10% 1/2W	1	
3-21	R325			MIL RC42GF104K	RESISTOR, Fixed composition, 100K ±10% 2W	1	
3-22	R324			MIL RC20GF184K	RESISTOR, Fixed composition, 180K ±10% 1/2W	1	
3-23	R326			MEC A2001F6A1	RESISTOR, Precision Per MEC Dwgs. A2001F6A1 and A2001F6A2, 300K ±1%	1	
3-24	R327			Chicago Telephone FF18378	POTENTIOMETER, Type 25, 20K	1	
3-25	R328			MEC A2001F6A1	RESISTOR, Precision Per MEC Dwgs. A2001F6A1 and A2001F6A2, 250K ±1%	1	
3-26	R329			MIL RC20GF181K	RESISTOR, Fixed composition, 180Ω ±10% 1/2W	1	
3-27	R330, R331 R332			MIL RC20GF104K	RESISTOR, Fixed composition, 100K ±10% 1/2W	3	

ITEM NO.	REFER. DESIG-NATOR	CLASS	STOCK NO.	MFG. AND PART NO.	DESCRIPTION	UNIT PER ASSY.	PROCURE-MENT CODE
3-28	R321			MIL RC20GF155K	RESISTOR, Fixed composition, 1.5M ±10% 1/2W	1	
3-29	R333, R334			MIL RC32GF473K	RESISTOR, Fixed composition, 47K ±10% 1W	2	
3-30	T301			Chicago Std. PMS-5S0 (MS90032)	TRANSFORMER, Power, 105/115/125VAC, 54-66 cps primary, 550-0-550 VAC, 250 ma dc Secondary, output 419V dc, Type TFRX02LB002.	1	
3-31	T302			MEC 1-102	TRANSFORMER	1	
3-32	V301-V303			Comm. 6550	TUBE, Electron	3	
3-33	V304, V305			Comm. 12AT7	TUBE, Electron	2	
3-34	V306, V307			Comm. OA2	TUBE, Electron	2	
3-35	XDS301 XDS302			Eldema 11H-4593	INDICATOR HOLDER	2	
3-36	XF301 XF302 XK303			Bussmann HKP	FUSEHOLDER	3	
3-37	XC303-XC307, XC309, XC310 XV301-XV303			JAN TX101P01	SOCKET, Tube Octal, Mica filled	10	
3-38	XV304 XV305			JAN TS103P01	SOCKET, Tube, 9 Pin Miniature, Mica filled	2	
3-39	XV306 XV307			JAN TS102P01	SOCKET, Tube, 7 Pin Miniature, Mica filled	2	
3-40				Eldema 11H-4118	LENS CAP, Amber	1	
3-41				Eldema 11H-4119	LENS CAP, Red	1	

ITEM NO.	REFER. DESIG-NATOR	CLASS	STOCK NO.	MFG. AND PART NO	DESCRIPTION 1 2 3 4 5 6 7	UNIT PER ASSY.	PROCURE-MENT CODE
4-1				MEC 1576-4A	ASSEMBLY, POWER SUPPLY, +250 V	1	
4-2	C401			Sangamo 7110-2R	CAPACITOR, Fixed, 2μf 1000 vdc	1	
4-3	C402, C403 C405			Aerovox AEP88J	CAPACITOR, Fixed Dual, 40-40μf 450 vdc Plug-In	3	
4-4	C404			Cornell Dubilier PM4P47	CAPACITOR, Fixed Mylar, .47μf 400 vdc	1	
4-5	CR401-CR408			G. E. 1N1695	DIODE	8	
4-6	DS401 DS402			Eldema 1CG12-4535	INDICATOR, Neon to Spec 21C-3864-7	2	
4-7	F403			Bussmann MDL	FUSE, 1/2 Amp., 250V, Slo-Blo	1	
4-8	F401, F402			Bussmann AGC	FUSE, 3 Amp.	2	
4-9	L401			Chicago Std. RH-8300	CHOKE, (Filter Reactor) 300 ma dc, 8 Hy 55Ω dc, Type TF4RX01YY	1	
4-10	P401			Cannon DD-50P	PLUG	1	
4-11	R401, R402			MIL RC20GF474K	RESISTOR, Fixed composition, 470K ±10% 1/2W	2	
4-12	R403-R405			MIL RC20GF101K	RESISTOR, Fixed composition, 100Ω ±10% 1/2W	3	
4-13	R406, R408 R410			MIL RC42GF470K	RESISTOR, Fixed composition, 47Ω ±10% 2W	3	
4-14	R407, R409 R411, R412, R414			MIL RC20GF102K	RESISTOR, Fixed composition, 1000Ω ±10% 1/2W	5	
4-15	R413, R418			MIL RC42GF823K	RESISTOR, Fixed composition, 82K ±10% 2W	2	
4-16	R416			MIL RC20GF334K	RESISTOR, Fixed composition, 330K ±10% 1/2W	1	
4-17	R417			MIL RC20GF684K	RESISTOR, Fixed composition, 680K ±10% 1/2W	1	
4-18	R419			MIL RC20GF184K	RESISTOR, Fixed composition, 180K ±10% 1/2W	1	
4-19	R420			MIL RC20GF754K	RESISTOR, Fixed composition, 750K ±10% 1/2W	1	
4-20	R422, R424			MEC A2001F6A1	RESISTOR, Precision Per MEC Dwgs. A2001F6A1 and A2001F6A2, 300K ±1%	2	
4-21	R423			Chicago Telephone FF18378	POTENTIOMETER, Type 25, 20K	1	
4-22	R421			MIL RC42GF104K	RESISTOR, Fixed composition, 100K ±10% 2W	1	
4-23	R425, R426			MIL RC20GF104K	RESISTOR, Fixed composition, 100K ±10% 1/2W	2	
4-24	R415			MIL RC20GF155K	RESISTOR, Fixed composition, 1.5M ±10% 1/2W	1	
4-25	T401			Chicago Std. PMS-550 (MS90032)	TRANSFORMER, Power, 105/115/125VAC, 54-66 cps primary, 550-0-550 VAC, 250 ma dc Secondary, output 419 vdc, Type TFRX02LB002.	1	
4-26	T402			MEC 1-102	TRANSFORMER	1	
4-27	V401-V403			Comm. 6550	TUBE, Electron	3	
4-28	V404, V405			Comm. 12AT7	TUBE, Electron	2	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	3 STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
4-29	XDS401 XDS402			Eldema 11H-4593	INDICATOR HOLDER	2	
4-30	XF401- XF403			Bussmann HKP	FUSEHOLDER	3	
4-31	XC401- XC403 XV401- XV403			JAN TS101P01	SOCKET, Tube Octal, Mica filled	6	
4-32	XV404 XV405			JAN TS103P01	SOCKET, Tube, 9 Pin Miniature, Mica filled	2	
4-33				Eldema 11H-4119	LENS CAP, Red	1	
4-34				Eldema 11H-4118	LENS CAP, Amber	1	
4-1				MEC 63-4C	ASSEMBLY, DC AMPLIFIER		
4-2	C402 C405 C413 C416			Cornell Dubilier PM4S5	CAPACITOR, Fixed Mylar, .05μf, 400vdc	4	
4-3	C403 C414			Southern Elect. Sec 1645	CAPACITOR, .1μf, Poly, ±20%, 200vdc	2	
4-4	C404 C415			MIL DM-15-271	CAPACITOR, Dura Mica, 270$\mu\mu$f, 500vdc	2	
4-5	C406 C417			MIL DM-15-101	CAPACITOR, Dura Mica, 100$\mu\mu$f, 500vdc	2	
4-6	C407 C409 C418 C420			Cornell Dubilier PM4S1	CAPACITOR, Fixed Mylar, .01μf, 400vdc	4	
4-7	C408 C419			MIL DM-15-150K	CAPACITOR, Dura Mica, 15$\mu\mu$f, 500vdc	2	
4-8	C410 C421			MIL DM-15-681K	CAPACITOR, Dura Mica, 680$\mu\mu$f, 500vdc, 10%	2	
4-9	C411 C422			MIL CP65B1EF105K	CAPACITOR, 1.0μf, 600vdc	2	

ITEM NO.	REFER. DESIG-NATOR	CLASS	STOCK NO.	MFG. AND PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNIT PER ASSY.	PROCURE-MENT CODE
4-10	C417 C421			MEC B63F4C1	ROLLOFF Network	2	
4-11	C423				CAPACITOR NOT USED IN THIS UNIT	1	
4-12	C424				CAPACITOR NOT USED IN THIS UNIT	1	
4-13	C425 C426			MIL DM-19-102K	CAPACITOR, Dura Mica, 1000uuf, 500vdc, 10%	2	
4-14	C427 C428			MEC B63F4C1	ROLLOFF Network	2	
4-15	CR401 CR402 CR405 CR407 CR408 CR411			Hughes HD6227	DIODE, Silicon	6	
4-16	CR403 CR404 CR409 CR410 CR406 CR412			MEC B63F4A	DIODE, Silicon	6	
4-17	DS402 DS404			Eldema 1CG12-4535	LAMP, Neon to Spec. 21C-3864-7	2	
4-18	DS401 DS403			Eldema NE-2	LAMP, Neon	2	
4-19	K401			Stevens Arnold CH-792	CHOPPER, DC-AC	1	
4-20	P401			Cannon DD-50P	PLUG, Male, 50 Pin Contact, 5 Amp Rating	1	
4-21	R401 R434			MIL RC20GF474K	RESISTOR, Fixed Composition, 470K, 10%, $\frac{1}{2}$W	2	
4-22	R402 R435			MIL RC20GF155K	RESISTOR, Fixed Composition, 1.5M, 10%, $\frac{1}{2}$W	2	
4-23	R403 R431 R436 R464			MIL RC20GF104K	RESISTOR, Fixed Composition, 100K, 10%, $\frac{1}{2}$W	4	
4-24	R404 R437			MIL RC20GF275K	RESISTOR, Fixed Composition, 2.7M, 10%, $\frac{1}{2}$W	2	
4-25	R405 R438			MIL RC20GF914J	RESISTOR, Fixed Composition, 910K, 5%, $\frac{1}{2}$W	2	
4-26	R406 R439			MIL RC20GF514J	RESISTOR, Fixed Composition, 510K, 5%, $\frac{1}{2}$W	2	
4-27	R407 R419 R440 R452			MIL RC20GF475K	RESISTOR, Fixed Composition, 4.7M, 10%, $\frac{1}{2}$W	4	
4-28	R408 R441			MIL RC20GF102K	RESISTOR, Fixed Composition, 1K, 10%, $\frac{1}{2}$W	2	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	 STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
4-29	R409 R421 R426 R442 R454 R459			MIL RC20GF334K	RESISTOR, Fixed Composition, 330K, 10%, ½W	6	
4-30	R410 R443			MIL RC20GF182K	RESISTOR, Fixed Composition, 1800 ohms, 10%, ½W	2	
4-31	R411 R444			MIL RC20GF473K	RESISTOR, Fixed Composition, 47K, 10%, ½W	2	
4-32	R412 R445			MIL RC20GF164J	RESISTOR, Fixed Composition, 160K, 5%, ½W	2	
4-33	R413 R446			MIL RC20GF563K	RESISTOR, Fixed Composition, 56K, 10%, ½W	2	
4-34	R414 R447			Allen Bradley JAIL040S504UC	POTENTIOMETER, 500K, 2W, Linear Taper	2	
4-35	R415 R448			MIL RC20GF125J	RESISTOR, Fixed Composition, 1.2M, 5%, ½W	2	
4-36	R416 R449			MIL RC20GF135J	RESISTOR, Fixed Composition, 1.3M, 5%, ½W	2	
4-37	R417			MEC B63F4C1	ROLLOFF Network	1	
4-38	R418 R451			MIL RC42GF184K	RESISTOR, Fixed Composition, 180K, 10%, 2W	2	
4-39	R420 R432 R453 R465			MIL RC20GF474K	RESISTOR, Fixed Composition, 470K, 10%, ½W	4	
4-40	R422 R455			MIL RC20GF124K	RESISTOR, Fixed Composition, 120K, 10%, ½W	2	
4-41	R423 R456			MIL RC20GF624J	RESISTOR, Fixed Composition, 620K, 5%, ½W	2	
4-42	R424				RESISTOR NOT USED IN THIS UNIT	1	
4-43	R425 R458			MIL RC20GF224K	RESISTOR, Fixed Composition, 220K, 10%, ½W	2	
4-44	R427 R460			MIL RC20GF135J	RESISTOR, Fixed Composition, 1.3M, 5%, ½W	2	
4-45	R428			MEC B63F4C1	ROLLOFF NETWORK	1	
4-46	R429 R462			MIL RC32GF222K	RESISTOR, Fixed Composition, 2200 ohms, 10%, 1W	2	
4-47	R430 R463			MIL RC32GF681K	RESISTOR, Fixed Composition, 680 ohm, 10%, 1W	2	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
4-48	R433 R466			MIL RC20GF226K	RESISTOR, Fixed Composition, 22M, 10%, $\frac{1}{2}$W	2	
4-49	R450 R461			MEC B63F4C1	ROLLOFF NETWORK	2	
4-50	R467			MIL RC42GF270K	RESISTOR, Fixed Composition, 27 ohms, 10%, 2W	1	
4-51	R468				RESISTOR NOT USED IN THIS UNIT	1	
4-52	S401 S402			Grayhill 35-1	SWITCH, Pushbutton, W/DAP (Black Button)	2	
4-53	TJ401 TJ402			H.H. Smith 1501-113	TEST JACK, (Gray)	2	
4-54	V403 V407			Comm. 7044	TUBE, Electron	2	
4-55	V402 V406			Comm. 6661	TUBE, Electron	2	
4-56	V401 V405			Comm. 6072	TUBE, Electron	2	
4-57	V404 V408			Comm. 6681	TUBE, Electron	2	
4-58	XDS402 XDS404			Eldema 1DH6-4591	INDICATOR, Holder	2	
4-59	XV403 XV404 XV407 XV408			JAN TS103P01	SOCKET, 9 Pin (Phenolic) Miniature	4	
4-60	XV401 XV405			JAN TS103C01	SOCKET, 9 Pin (Ceramic) Miniature	2	
4-61	XV402 XV406			JAN TS102P01	SOCKET, 7 Pin (Phenolic) Miniature	2	
4-62	XV409			JAN TS101P01	SOCKET, Octal, (Phenolic)	1	
4-63				JAN TS103U03	SHIELD, Tube	2	
4-64				JAN TS103U02	SHIELD, Tube	4	
4-65				JAN TS102U02	SHIELD, TUBE	2	
4-66				Eldema 1DH6-4591	LENS CAP (Translucent)	2	

ITEM NO.	REFER. DESIG-NATOR	CLASS	STOCK NO.	MFG. AND PART NO.	DESCRIPTION	UNIT PER ASSY.	PROCURE-MENT CODE
5-1				MEC 1576-5A	ASSEMBLY, DATA SUMMING	1	
5-2	C501			Cornell Dubilier PM4P1	CAPACITOR, Fixed Mylar, .1μf, 400vdc	1	
5-3	C502			Cornell Dubilier PM4P5	CAPACITOR, Fixed Mylar, .5μf, 400vdc	1	
5-4	DS501-DS510			Eldema 1CG12-4535	LAMP, Neon to Spec. 21C-3864-7	10	
5-5	K501 K509			MEC RY-13	RELAY, Mercury Wetted	9	
5-6	K510 K511			MEC RY-12	RELAY, Mercury Wetted	2	
5-7	P501			Cannon DD-50P	PLUG, Male, 50 Pin Contact, 5 amp Rating	1	
5-8	P502			Winchester Q-RE-34S-LT	CONNECTOR, with stainless steel locking screws	1	
5-9	R515-R525			MIL RC20GF752K	RESISTOR, Fixed Composition, 7.5K, 10%, 1/2W	11	
5-10	R526-R535			MIL RC20GF393K	RESISTOR, Fixed Composition, 39K, 10%, 1/2W	10	
5-11	R536-R546			MIL RC32GF112K	RESISTOR, Fixed Composition, 1.1K, 10%, 1W	11	
5-12	R547			Ward Leonard 5X6000	RESISTOR, Axiohm, 6K, 5W	1	
5-13	TJ501			Cannon DD-50S	CONNECTOR, Female, 50 Pin Contact, 5 amp Rating	1	
5-14	XDS501-XDS510			Eldema 11H4593	INDICATOR, Holder	10	
5-15	XK501-XK511			JAN TS101PO1	SOCKET, Octal, Mica Filled	11	
5-16				Eldema 11H-4110	LENS CAP (Translucent)	10	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	3 STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE	8 UNIT COST (EST.)
7-1				MEC 1576-7A	ASSEMBLY, 20 BIT SHIFT REGISTER	1		
7-2	C701			MIL CM-19B-102K	CAPACITOR, Fixed Mica, 1000 $\mu\mu$f, 500vdc	1		.42
7-3	C702			Cornell Dubilier PM4S1	CAPACITOR, Fixed Mylar, .01μf, 400vdc	1		.21
7-4	C703			MIL CM-19B-471K	CAPACITOR, Fixed Mica, 470$\mu\mu$f, 500vdc	1		.28
7-5	C704			Fansteel F110-1	CAPACITOR, (Blu-Cap) 10μf, 25vdc	1		3.64
7-6	C705			Fansteel F308-1	CAPACITOR, (Blu-Cap) 100μf, 30vdc	1		9.38
7-7	C706			Cornell Dubilier PM4D5	CAPACITOR, Fixed Mylar, .005μf, 400vdc	1		.21
7-8	CR701 CR702			Transitron T12G or Clevite CTP-503	DIODE	2		1.26
7-9	M701-M720			MEC MN-11	CORE, Magnetic	20		17.11
7-10	M721			MEC MN-13	CORE, Magnetic	1		17.11
7-11	N701-N720			MEC TN-28	TRANSISTOR NETWORK	20		29.42
7-12	N721			MEC TN-130B	TRANSISTOR NETWORK	1		37.10
7-13	N722 N723			MEC TN-138B	TRANSISTOR NETWORK	2		43.29
7-14	P701			Cannon DD-50P	PLUG, Male 50 Pin Contact, 5 amp Rating	1		5.85
7-15	R701 R702 R706 R707			MIL RC20GF103K	RESISTOR, Fixed Composition, 10K, 10%, 1/2W	4		.17
7-16	R703			MIL RC20GF161J	RESISTOR, Fixed Composition, 160Ω, 5%, 1/2W	1		.34
7-17	R704			MIL RC20GF332K	RESISTOR, Fixed Composition, 3.3K, 10%, 1/2W	1		.17
7-18	R705			MIL RC20GF163J	RESISTOR, Fixed Composition, 16K, 5%, 1/2W	1		.34
7-19	R708			MIL RC20GF162J	RESISTOR, Fixed Composition, 1.6K, 5%, 1/2W	1		.34
7-20	TJ701			Cannon DD-50S	CONNECTOR, Female, 50 Pin contact, 5 amp Rating	1		9.60

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	3 STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE	8 UNIT COST (EST.)
7-21	XM701 XM721			JAN TS103PO2	SOCKET, 9 Pin Miniature Mica filled	21		.46
7-22	XN701-XN723			JAN TS101PO1	SOCKET, Octal, Mica filled	23		.67
6-1				MEC 1576-6A	ASSEMBLY, CONTROL	1		
6-2	C601			Cornell Dubilier PM4P1	CAPACITOR, Fixed Mylar, .1µf, 400vdc	1		.29
6-3	C602			Cornell Dubilier PM4P47	CAPACITOR, Fixed Mylar, .47µf, 400vdc	1		.67
6-4	C603, C606, C608, C609, C619, C622, C627, C628, C632, C633			MIL CM-19B-102K	CAPACITOR, Fixed Mica, 1000µµf, 10%, 500vdc	10		.42
6-5	C604 C631			MIL CM-19B-331K	CAPACITOR, Fixed Mica, 330µµf, 10%, 500vdc	2		.28
6-6	C605 C611 C612 C614			MIL CM-19B-681K	CAPACITOR, Fixed Mica, 680µµf, 10%, 500vdc	4		.32
6-7	C615			Cornell Dubilier PM4S12	CAPACITOR, Fixed Mylar, .012µf, 400vdc	1		.21
6-8	C610 C620 C623 C629 C630			Fansteel F110-1	CAPACITOR, (Blu-cap) 10µf, 25vdc	5		3.64

ITEM NO.	REFER. DESIG-NATOR	CLASS	STOCK NO.	MFG. AND PART NO.	DESCRIPTION	UNIT PER ASSY.	PROCURE-MENT CODE	UNIT COST (EST.)
6-9	C613			MIL CM-19B-821K	CAPACITOR, FIXED MICA, 820μμf, 10%, 500 vdc	1		
6-10	C616 C618 C621			MIL CM-19B-561K	CAPACITOR, FIXED MICA, 560μμf, 10%, 500 vdc	3		
6-11	C617			Fansteel F121-1	CAPACITOR, (Blu Cap) 1.5μf, 125vdc	1		
6-12	C607 C624 C625			Cornell Dubilier PM4S1	CAPACITOR, FIXED MYLAR, .01μf, 400vdc	3		
6-13	C626			Cornell Dubilier PM4P5	CAPACITOR, FIXED MYLAR, .5μf, 400vdc	1		
6-13A	C627			MIL CP65B1EF105K	CAPACITOR, FIXED, 1μf, 600vdc	1		
6-14	CR601-CR606, CR608-CR612, CR614, CR619, CR622, CR627-CR633			Transitron T12G or Clevite CTP-503	DIODE	25		
6-15	CR607			International Rectifier 1N1524	DIODE, Zener, 12V (1Z12)	1		
4A-6 59								
6-16	CR613 CR620 CR621 CR623			International Rectifier IN1523	DIODE, Zener, 10v (1Z10)	4		
6-17	CR624			International Rectifier IN1519	DIODE, Zener, 4.7v (1Z4.7)	1		
6-18	CR625 CR626			G-E IN1695	DIODE	2		
6-19	DS601			Eldema 1CG12-4535	LAMP, Neon to Spec. 21C-3864-7	1		
6-20	I601			Dialight S6	LAMP, Incandescent, Bayonet type, 24v, 6W	1		
6-21	M601 M602			MEC MN-12	CORE, Magnetic	2		
6-22	M603			MEC MN-11	CORE, Magnetic	1		
6-23	MV601			Beede E25	METER, 1.2 MA (scale 0-12) Horizontal Mounting	1		
6-24	N601 N608			MEC TN-57	TRANSISTOR Network	2		

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE	8 UNIT COST (EST.)
6-25	N602- N605 N609 N610 N612 N613 N615			MEC TN-138B	TRANSISTOR Network	10		
6-26	N611			MEC TN-130B	TRANSISTOR Network	1		
6-27	N616			MEC TN-42A	TRANSISTOR Network	1		
6-28	N607			MEC TN-58	TRANSISTOR Network	1		
6-29	N617			MEC RN-44	RESISTOR Network	1		
6-30	N606 N614			MEC TN-90B	TRANSISTOR Network	2		
6-31	P601			Cannon DD-50P	PLUG, Male, 50 pin contact, 5 amp Rating	2		
6-32	R601 R606 R619			MIL RC20GF910J	RESISTOR, Fixed composition, 91 Ω, 5%, 1/2W	3		
A-6 59								
6-33	R602 R620 R621 R623 R628 R639- R641 R643 R659			MIL RC20GF103K	RESISTOR, Fixed composition, 10K, 10%, 1/2W	10		
6-34	R603 R609- R611 R622 R624 R625 R634 R635 R655 R633			MIL RC20GF473K	RESISTOR, Fixed composition, 47K, 10%, 1/2W	11		
6-35	R604 R613 R636 R664			MIL RC20GF153K	RESISTOR, Fixed composition, 15K, 10%, 1/2W	4		
6-36	R605			MIL RC20GF393K	RESISTOR, Fixed composition, 39K, 10%, 1/2W	1		
6-37	R607			MIL RC20GF273K	RESISTOR, Fixed composition, 27K, 10%, 1/2W	1		

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
6-38	R608 R658 R612 R614 R615 R627 R631			MIL RC20GF222K	RESISTOR, Fixed Composition, 2.2K, 10%, 1/2W	7	
6-39	R616 R618			MIL RC32GF271K	RESISTOR, Fixed Composition, 270Ω, 10%, 1W	2	
6-40	R617 R653 R657			MIL RC20GF472K	RESISTOR, Fixed Composition, 4.7K, 10%, 1/2W	3	
6-41	R629			MIL RC20GF621K	RESISTOR, Fixed Composition, 620Ω, 10%, 1/2W	1	
6-42	R630			MIL RC20GF183K	RESISTOR, Fixed Composition, 18K, 10%, 1/2W	1	
6-43	R632 R633			MIL RC20GF102K	RESISTOR, Fixed Composition, 1K, 10%, 1/2W	2	
6-44	R637			MIL RC20GF333K	RESISTOR, Fixed Composition, 33K, 10%, 1/2W	1	
6-45	R638 R642			MIL RC20GF332K	RESISTOR, Fixed Composition, 3.3K, 10%, 1/2W	2	
6-46	R626			MIL RC20GF223K	RESISTOR Fixed Composition, 22K, 10%, 1/2W	1	
6-47	R644			MIL RC20GF471K	RESISTOR Fixed Composition, 470Ω, 10%, 1/2W	1	
6-48	R645			Phaostron CA4RS-1/2	RESISTOR Precision, 51.8K, 1%, 1/2W	1	
6-49	R646			Phaostron CA4RS-1/2	RESISTOR Precision, 20K, 1%, 1/2W	1	
6-50	R647			Phaostron CA4RS-1/2	RESISTOR Precision, 70K, 1%, 1/2W	1	
6-51	R648			Phaostron CA4RS-1/2	RESISTOR Precision, 560K, 1%, 1/2W	1	
6-52	R649			Phaostron CA4RS-1/2	RESISTOR Precision, 3.9K, 1%, 1/2W	1	
6-53	R650			Phaostron CA4RS-1/2	RESISTOR Precision, 250K, 1%, 1/2W	1	
6-54	R651			Phaostron CA4RS-1/2	RESISTOR Precision, 12K, 1%, 1/2W	1	
6-55	R652			Phaostron CA4RS-1/2	RESISTOR Precision, 35K, 1%, 1/2W	1	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
6-56	R656			MIL RC20GF101K	RESISTOR, Fixed Composition, 100Ω, 10%, 1/2 W	1	
6-57	R660 R661 R662			MIL RC20GF104K	RESISTOR, Fixed Composition, 100K, 10%, 1/2 W	3	
6-58	S601			Centralab PA-2027	SWITCH, ROTARY, 8 Pole, 2-6 Positions, Non-Shorting, Ceramic	1	
6-59	S602			Micro 2PB11	SWITCH, Pushbutton	1	
6-60	S603			Centralab PA-2005	SWITCH, Rotary, 2 Pole, 2-12 Positions, non-Shorting, Ceramic	1	
6-61	S604 S605 S606			Carling 2GL63-73	SWITCH, Toggle, DPDT, On-None-On	3	
6-62	SC601			Weston D-845A	REFERENCE CELL	1	
6-63	TJ601 TJ602			Cannon DD-50S	CONNECTOR, Female, 50 pin contact 5 amp rating	2	
6-64	XDS601			Eldema 11H4593	INDICATOR HOLDER	1	
6-65	XI601			Dialight 103-3502-1211	INDICATOR HOLDER, Dome Type, Clear, Red Lens for S6 Bayonet Type Lamp	1	
6-66	XM601-XM603			JAN TS103P02	SOCKET, 9 pin miniature, mica filled	3	
6-67	XN601-XN616			JAN TS101P01	SOCKET, Octal, Mica filled	16	
6-68	XN617			Amphenol 78-S11T	SOCKET, 11 pin, Mica filled	1	
6-69				Whitso K-105	KNOB	2	
6-70				Eldema 11H-4110	LENS CAP (Translucent)	1	

ITEM NO. (1)	REFER. DESIG-NATOR (2)	CLASS (3)	STOCK NO. (3)	MFG. AND PART NO. (4)	DESCRIPTION 1 2 3 4 5 6 7 (5)	UNIT PER ASSY. (6)	PROCURE-MENT CODE (7)
4-1				MEC 165-4A	ASSEMBLY, POWER SUPPLY	1	
4-2	C401, C402 C421-C423 C441 C442			Mallory 20-71860	CAPACITOR, Computer Grade, 3000μf 75 vdc 2-1/16 x 4-1/2 Alum. can with Acetate Sleeve	7	
4-3	C403 C425 C443 C444			Cornell Dubilier PM4S1	CAPACITOR, Fixed Mylar, .01μf 400 vdc	4	
4-4	C424			Cornell Dubilier PM4P1	CAPACITOR, Fixed Mylar, .1μf 400 vdc	1	
4-5	C404 C426 C445 C446			Fansteel F308-1	CAPACITOR, (Blu-Cap) 100μf 30 vdc	4	
4-6	CR401 CR421 CR441			G. E. 4JA211AB1AC2	RECTIFIER	3	
4-7	CR402 CR422			International Rectifier IN1519	DIODE, Zener (1Z4.7)	2	
4-8	CR442			International Rectifier IN1524	DIODE, Zener (1Z12)	1	
4-9	F401 F403			Bussmann AGC	FUSE, 1 Amp	2	
4-10	F402			Bussmann AGC	FUSE, 3 Amp	1	
4-11	F404			Bussmann MDX	FUSE, Fusetron, Slo-Blo, 3 Amp	1	
4-12	P401			Cannon DD-50P	PLUG	1	
4-13	Q423 Q442			Delco 2N553	TRANSISTOR (Mount with Parts 100 & 101)	2	
4-14	Q401 Q421 Q441			Delco 2N443	TRANSISTOR (Lug type Leads)	3	
4-15	Q402 Q403 Q424 Q443			G. E. 2N525	TRANSISTOR	4	
4-16	Q404 Q425 Q444			Sylvania 2N576A	TRANSISTOR	3	
4-17	R401 R402 R421A R421B R441 R442			Ward Leonard 5X1	RESISTOR, Fixed Axiohm, 1Ω 5W	6	
4-18	R403 R443			Ward Leonard 5X2	RESISTOR, Fixed Axiohm, 2Ω 5W	2	
4-19	R404 R425 R444			MIL RC42GF102K	RESISTOR, Fixed composition, 1K ±10% 2W	3	

1 ITEM NO.	2 REFER. DESIG-NATOR	3 CLASS	STOCK NO.	4 MFG. AND PART NO.	5 DESCRIPTION 1 2 3 4 5 6 7	6 UNIT PER ASSY.	7 PROCURE-MENT CODE
4-20	R405 R434			MIL RC42GF151K	RESISTOR, Fixed composition, 150Ω ±10% 2W	2	
4-21	R406			MIL RC20GF681K	RESISTOR, Fixed composition, 680Ω ±10% 1/2W	1	
4-22	R407 R428 R447			MIL RC20GF101K	RESISTOR, Fixed composition, 100Ω ±10% 1/2W	3	
4-23	R408			MIL RC20GF122K	RESISTOR, Fixed composition, 1.2K ±10% 1/2W	1	
4-24	R409 R430 R449			MIL RC20GF822K	RESISTOR, Fixed composition, 8.2K ±10% 1/2W	3	
4-25	R410 R431 R450			MIL RC20GF621J	RESISTOR, Fixed composition, 620Ω ±5% 1/2W	3	
4-26	R411 R432			MIL RC20GF472K	RESISTOR, Fixed composition, 4.7K ±10% 1/2W	2	
4-27	R412 R413			MIL RC32GF121K	RESISTOR, Fixed composition, 120Ω ±10% 1W	2	
4-28	R414 R435			Allen Bradley JLU-5001 or JA1L040S500UC	POTENTIOMETER, 50Ω 2W, Linear Taper	2	
4-29	R415			MIL RC32GF820K	RESISTOR, Fixed composition, 82Ω ±10% 1W	1	
4-30	R416			MIL RC42GF221K	RESISTOR, Fixed composition, 220Ω ±10% 2W	1	
4-31	R422			Ward Leonard 10F1	RESISTOR, Fixed, Wire wound, 1Ω 10W	1	
4-32	R423 R424			Ward Leonard 10F2	RESISTOR, Fixed, Wire wound, 2Ω 10W	2	
4-33	R426 R445			Ward Leonard 10F150	RESISTOR, Fixed, Wire wound, 150Ω 10W	2	
4-34	R427 R446			MIL RC32GF681K	RESISTOR, Fixed composition, 680Ω ±10% 1W	2	
4-35	R429 R448			MIL RC32GF122K	RESISTOR, Fixed composition, 1.2K ±10% 1W	2	
4-36	R433			MIL RC42GF271K	RESISTOR, Fixed composition, 270Ω ±10% 2W	1	
4-37	R436			MIL RC32GF470K	RESISTOR, Fixed composition, 47Ω ±10% 1W	1	
4-38	R437			Ward Leonard 10F100	RESISTOR, Fixed, Wire wound, 100Ω 10W	1	
4-39	R451			MIL RC42GF182K	RESISTOR, Fixed composition, 1.8K ±10% 2W	1	
4-40	R453			Allen Bradley JLU-5011 or JA1L040S501UC	POTENTIOMETER, 500Ω 2W, Linear Taper	1	
4-41	R454			MIL RC32GF362J	RESISTOR, Fixed composition, 3.6K ±5% 1W	1	
4-42	R455			Ward Leonard 5X500	RESISTOR, Fixed Axiohm, 500Ω 5W	2	
4-43	R452			MIL RC32GF112J	RESISTOR, Fixed composition, 1.1K ±5% 1W	1	
4-44	T401			TTI 5486	TRANSFORMER	1	

1	2	3		4	5	6	7
ITEM NO.	REFER. DESIG-NATOR	CLASS	STOCK NO.	MFG. AND PART NO.	DESCRIPTION 1 2 3 4 5 6 7	UNIT PER ASSY.	PROCURE-MENT CODE
4-45	TJ401-TJ404			H.H. Smith 221	JACK, Midget Banana (Black)	4	
4-46	XF401-XF404			Bussmann HKP	FUSE HOLDER	4	
1				McLean 2EB508C	ASSEMBLY, BLOWER	1	

CHAPTER VIII

WIRE LIST

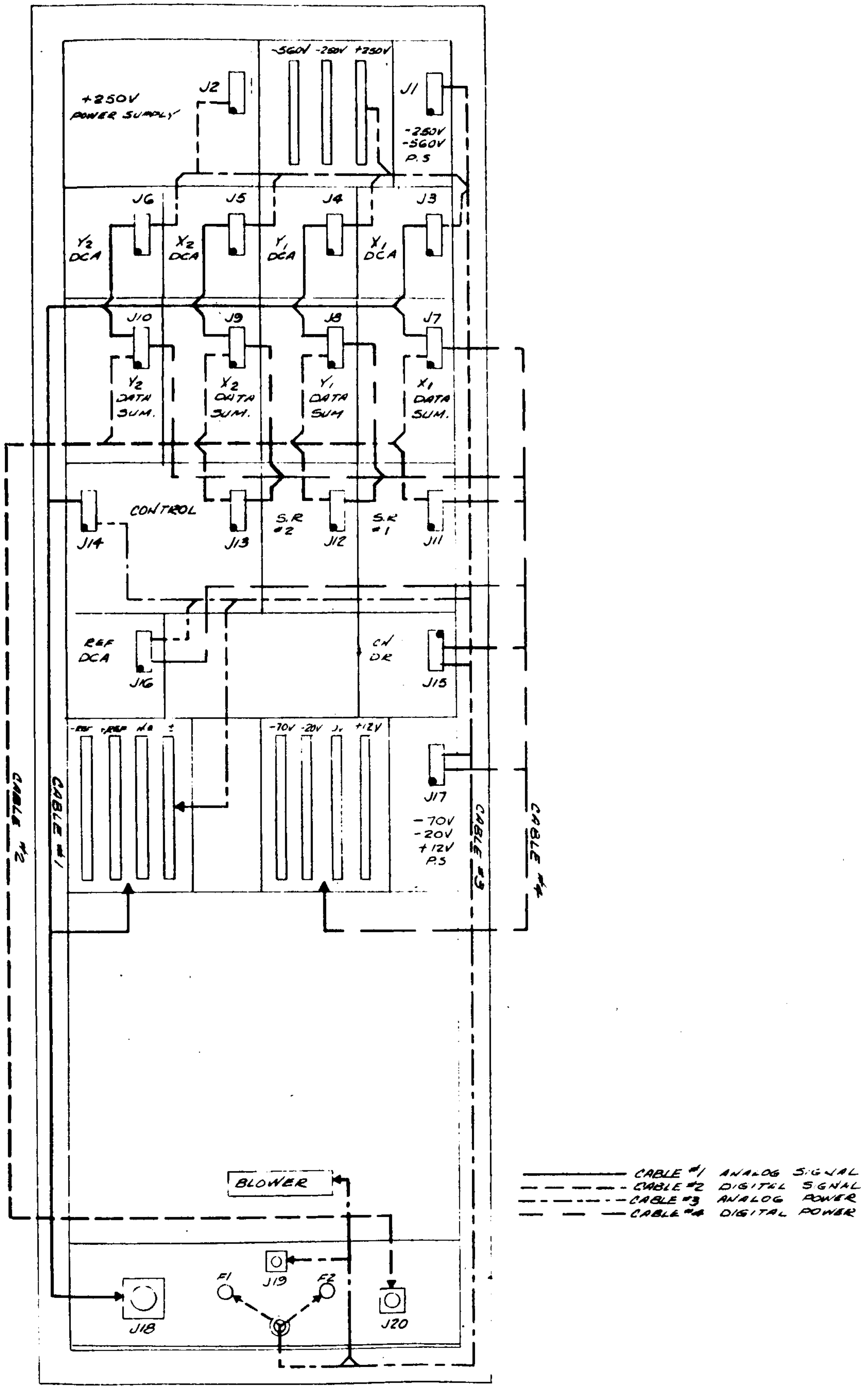


Figure 8-1. Cabling Diagram

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J1
-250V, -560V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J19-B	3	120VAC Common	18	W
	2	J2-1	3	120VAC Common	18o	W
	3					
	4					
	5					
	6					
	7					
	8					
	9	J16-45	3	Fil #2A	20*	W-BR
	10	J6-45	3	Fil #2A	18#	W-BR
	11					
	12					
	13	-250-1	3	-250V	20	W
	14			-250V		
	15					
	16					
	17	-560-1	3	-560V	20	V
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES: * Twisted Triple
\# Twisted Triple
o Twisted Triple

J1
-250V, -560V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26	J16-47	3	Fil #2 CT (-125V)	20*	W
	27	J6-47	3	Fil #2 CT (-125V)	18#	W
	28					
	29					
	30					
	31					
	32					
	33	J14-29	3	120VAC Ø2 Switched	18	W-S
	34	J2-34	3	120VAC Ø2 Switched	18o	W-S
	35					
	36	J14-32	3	120VAC Ø1 Switched	18	S
	37	J2-37	3	120VAC Ø1 Switched	18o	S
	38					
	39					
	40					
	41					
	42	J16-49	3	Fil #2B	20*	BR
	43	J6-49	3	Fil #2B	18#	BR
	44					
	45					
	46					
	47	±-2	3	±	20	BK
	48			±		
	49					
	50	Frame		Chassis Ground	22	BK

NOTES: * Twisted Triple
\# Twisted Triple
o Twisted Triple

J1
-250V, -560V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1					
	2					
	9					
	10					
	13					
	14					
	26					
	27					
	36					
	37					
	42					
	43					
	47					
	48					

NOTES: JUMPER CONNECTIONS

J2
+250V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J1-2	3	120VAC Common	18^{o}	W
	2			120VAC Common		
	3					
	4					
	5					
	6					
	7					
	8					
	9	J16-14	3	Fil #1A	$20^{\prime}$	W-BR
	10	J6-15	3	Fil #1A	20π	W-BR
	11					
	12					
	13	±-3	3	±	20	BK
	14			±		
	15					
	16	-250-2	3	-250V	20	W
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES: o Twisted Triple
' Twisted Pair
π Twisted Pair

J2
+250V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26	±-4	3	Fil #1 CT (Gnd)	20	BK
	27			Fil #1 CT (Gnd)		
	28					
	29					
	30					
	31					
	32					
	33			120VAC $\emptyset_2$ Switched		
	34	J1-34	3	120VAC $\emptyset_2$ Switched	18°	W-S
	35					
	36			120VAC $\emptyset_1$ Switched		
	37	J1-37	3	120VAC $\emptyset_1$ Switched	18°	S
	38					
	39					
	40					
	41					
	42	J16-16	3	Fil #1B	20'	BR
	43	J6-17	3	Fil #1B	20π	BR
	44					
	45					
	46					
	47	+250-1	3	+250V	20	R
	48			+250V		
	49					
	50	Frame		Chassis Ground	22	BK

NOTES: o Twisted Triple
' Twisted Pair
π Twisted Pair

J2
+250V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1					
	2					
	9					
	10					
	13					
	14					
	26					
	27					
	36					
	37					
	42					
	43					
	47					
	48					

NOTES: JUMPER CONNECTIONS

J3
X_1 DC AMPS #3 and #4

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J7-2	Direct	Input, Amp A (#3)	Coax	
	2			H.Q. Ground		
	3					
	4	J7-4	1	Output, Amp A (#3)	22	O
	5			Boost, Amp A		
	6	J7-37	1	Output, Amp B (#4)	20	Y
	7			Boost, Amp B		
	8					
	9	-560-4	3	-560V	22	V
	10			-560V		
	11					
	12	+250-4	3	+250V	22	R
	13			+250V		
	14	J4-14	3	Fil #1A	20°	W-BR
	15			Fil #1A		
	16	J4-16	3	Fil #1B	20°	BR
	17			Fil #1B		
	18	H.Q._4	1	H.Q. Ground	20	BK
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES: (°) Twisted Pair

J3
X_1 DC AMPS #3 and #4

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34	J7-35	Direct	Input, Amp B (#4)	Coax	
	35	Frame		Chassis Ground	22	BK
	36			Overload, Amp B	22	
	37	±-7	3	±	22	BK
	38			Overload, Amp A	20	
	39	-250-5	3	-250V	22	W
	40			-250V		
	41	J4-41	3	Chopper Drive (Hot)	22'	BR
	42			Chopper Drive (Hot)		
	43	J4-43	3	Chopper Drive (Gnd)	22'	W-BR
	44			Chopper Drive (Gnd)		
	45			Fil #2A		
	46	J4-46	3	Fil #2A	18*	W-BR
	47			Fil #2CT (-125V)		
	48	J4-48	3	Fil #2CT (-125V)	18*	W
	49			Fil #2B		
	50	J4-50	3	Fil #2B	18*	BR

NOTES:
(*) Twisted Triple
(') Twisted Pair

J3
X_1 DC Amps #3 and #4

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	2					
	18					
	9					
	10					
	12					
	13					
	14					
	15					
	16					
	17					
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47					
	48					
	49					
	50					

NOTES: JUMPER CONNECTIONS

J4
Y_1 DC AMPS #5 and #6

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J8-2	Direct	Input, Amp A (#5)	Coax	
	2			H.Q. Ground		
	3					
	4	J8-4	1	Output, Amp A (#5)	22	G
	5			Boost, Amp A		
	6	J8-37	1	Output, Amp B (#6)	20	BL
	7			Boost, Amp B		
	8					
	9	-560-5	3	-560V	22	V
	10			-560V		
	11					
	12	+250-5	3	+250V	22	R
	13			+250V		
	14	J3-14	3	Fil #1A	$20^{\bullet}$	W-BR
	15	J5-15	3	Fil #1A	20^{π}	W-BR
	16	J3-16	3	Fil #1B	$20^{\bullet}$	BR
	17	J5-17	3	Fil #1B	20^{π}	BR
	18	H.Q.-5	1	H.Q. Ground	20	BK
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES: ($\bullet$) Twisted Pair
(π) Twisted Pair

J4
Y_1 DC AMPS #5 and #6

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34	J8-35	Direct	Input, Amp B (#6)	Coax	
	35	Frame		Chassis Ground	22	BK
	36			Overload, Amp B	22	
	37	±-8	3	±	22	BK
	38			Overload, Amp A		
	39	-250-6	3	-250V	22	W
	40			-250V		
	41	J3-41	3	Chopper Drive (Hot)	22'	BR
	42	J5-42	3	Chopper Drive (Hot)	22"	BR
	43	J3-43	3	Chopper Drive (Gnd)	22'	W-BR
	44	J5-44	3	Chopper Drive (Gnd)	22"	W-BR
	45	J5-45	3	Fil #2A	18#	W-BR
	46	J3-46	3	Fil #2A	18*	W-BR
	47	J5-47	3	Fil #2CT (-125V)	18#	W
	48	J3-48	3	Fil #2CT (-125V)	18*	W
	49	J5-49	3	Fil #2B	18#	BR
	50	J3-50	3	Fil #2B	18*	BR

NOTES:
(#) Twisted Triple
(*) Twisted Triple
(') Twisted Pair
(") Twisted Pair

J4
Y_1 DC AMPS #5 and #6

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	2					
	18					
	9					
	10					
	12					
	13					
	14					
	15					
	16					
	17					
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47					
	48					
	49					
	50					

NOTES: JUMPER CONNECTIONS

J5

X_2 DC AMPS #7 and #8

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J9-2	Direct	Input, Amp A (#7)	Coax	
	2			H.Q. Ground		
	3					
	4	J9-4	1	Output, Amp A (#7)	22	V
	5			Boost, Amp A		
	6	J9-37	1	Output, Amp B (#8)	20	BL
	7			Boost, Amp B		
	8					
	9	-560-6	3	-560V	22	V
	10			-560V		
	11					
	12	+250-6	3	+250V	22	R
	13			+250V		
	14	J6-14	3	Fil #1A	20µ	W-BR
	15	J4-15	3	Fil #1A	20π	W-BR
	16	J6-16	3	Fil #1B	20µ	BR
	17	J4-17	3	Fil #1B	20π	BR
	18	H.Q.-6	1	H.Q. Ground	20	BK
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES: (µ) Twisted Pair
(π) Twisted Pair

J5

X_2 DC AMPS #7 and #8

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34	J9-35	Direct	Input, Amp B (#8)	Coax	
	35	Frame		Chassis Ground	22	BK
	36			Overload, Amp B		
	37	±-9	3	±	22	BK
	38			Overload, Amp A		
	39	-250-7	3	-250V	22	W
	40			-250V		
	41	J6-41	3	Chopper Drive (Hot)	22'	BR
	42	J4-42	3	Chopper Drive (Hot)	22"	BR
	43	J6-43	3	Chopper Drive (Gnd)	22'	W-BR
	44	J4-44	3	Chopper Drive (Gnd)	22"	W-BR
	45	J4-45	3	Fil #2A	18#	W-BR
	46	J6-46	3	Fil #2A	18*	W-BR
	47	J4-47	3	Fil #2CT (-125V)	18#	W
	48	J6-48	3	Fil #2CT [-125V)	18*	W
	49	J4-49	3	Fil #2B	18#	BR
	50	J6-50	3	Fil #2B	18*	BR

NOTES: (#) Twisted Triple
(*) Twisted Triple
(') Twisted Pair
(") Twisted Pair

J5

X_2 DC AMPS #7 and #8

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	2					
	18					
	9					
	10					
	12					
	13					
	14					
	15					
	16					
	17					
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47					
	48					
	49					
	50					

NOTES:
JUMPER CONNECTIONS

J6

Y_2 DC AMPS #9 and #10

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J10-2	Direct	Input, Amp A (#9)	Coax	
	2			H.Q. Ground		
	3					
	4	J10-4	1	Output, Amp A (#9)	22	W
	5			Boost, Amp A		
	6	J10-37	1	Output, Amp B (#10)	20	W-BL
	7			Boost, Amp B		
	8					
	9	-560-7	3	-560V	22	V
	10			-560V		
	11					
	12	+250-7	3	+250V	22	R
	13			+250V		
	14	J5-14	3	Fil #1A	20^{μ}	W-BR
	15	J2-10	3	Fil #1A	20^{π}	W-BR
	16	J5-16	3	Fil #1B	20^{μ}	BR
	17	J2-43	3	Fil #1B	20^{π}	BR
	18	H.Q.-7	1	H.Q. Ground	20	BK
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES: (μ) Twisted Pair
(π) Twisted Pair

J6

Y_2 DC AMPS #9 and #10

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34	J10-35	Direct	Input, Amp B (#10)	Coax	
	35	Frame		Chassis Ground	22	BK
	36			Overload, Amp B		
	37	±-10	3	±	22	BK
	38			Overload, Amp A		
	39	-250-8	3	-250V	22	W
	40			-250V		
	41	J5-41	3	Chopper Drive (Hot)	22'	BR
	42	J16-42	3	Chopper Drive (Hot)	22"	BR
	43	J5-43	3	Chopper Drive (Gnd)	22'	W-BR
	44	J16-44	3	Chopper Drive (Gnd)	22"	W-BR
	45	J1-10	3	Fil #2A	18#	W-BR
	46	J5-46	3	Fil #2A	18*	W-BR
	47	J1-27	3	Fil #2CT (-125V)	18#	W
	48	J5-48	3	Fil #2CT (-125V)	18*	W
	49	J1-43	3	Fil #2B	18#	BR
	50	J5-50	3	Fil #2B	18*	BR

NOTES: (#) Twisted Triple
(*) Twisted Triple
(') Twisted Pair
(") Twisted Pair

J6

Y_2 DC AMPS #9 and #10

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	2					
	18					
	9					
	10					
	12					
	13					
	14					
	15					
	16					
	17					
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47					
	48					
	49					
	50					

NOTES: JUMPER CONNECTIONS

J7

X_1 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	Frame		Chassis Ground	22	BK
	2	J3-1	Direct	Input Amp "A"	Coax	
	3			Chassis Ground		
	4	J3-4	1	Output Amp "A"	22	O
	5					
	6			Holding Relay Signal		
	7	J8-7	2	Holding Relay Signal	22	W-Y
	8	J11-1	2	BIT #40 (512)	22	W-BR
	9	J11-2	2	BIT #39 (256)	22	W-R
	10	J11-3	2	BIT #38 (128)	22	W-O
	11	J11-4	2	BIT #37 (64)	22	W-Y
	12	J11-5	2	BIT #36 X_1 (32)	22	W-G
	13	J11-6	2	BIT #35 (16)	22	W-BL
	14	J11-7	2	BIT #34 (8)	22	W-V
	15	J11-8	2	BIT #33 (4)	22	W-S
	16	J11-9	2	BIT #32 (2)	22	W
	17	J11-10	2	BIT #31 (1)	22	W-BK
	18			Chassis Ground		
	19			Chassis Ground		
	20			Chassis Ground		
	21					
	22					
	23					
	24					
	25					

NOTES:

J7

X_1 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33	+ Ref-4	1	+ Ref. Voltage	20	W-R
	34			Chassis Ground		
	35	J3-34	Direct	Input Amp "B"	Coax	
	36			Chassis Ground		
	37	J3-6	1	Output Amp "B"	20	Y
	38	J18-N	1	Output Amp "B" (X_1 Output)	20	Y
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47	-20-4	4	-20V	20	S
	48					
	49	-70-2	4	-70V	20	W-BK
	50					

NOTES:

J7
X_1 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	37					
	38					
	6					
	7					

NOTES:

JUMPER CONNECTIONS

J8
Y_1 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	Frame		Chassis Ground	22	BK
	2	J4-1	Direct	Input Amp "A"	Coax	
	3			Chassis Ground		
	4	J4-4	1	Output Amp "A"	22	G
	5					
	6	J9-6	2	Holding Relay Signal	22	W-Y
	7	J7-7	2	Holding Relay Signal	22	W-Y
	8	J11-11	2	BIT #30 (512)	22	W-BR
	9	J11-12	2	BIT #29 (256)	22	W-R
	10	J11-13	2	BIT #28 (128)	22	W-O
	11	J11-14	2	BIT #27 (64)	22	W-Y
	12	J11-15	2	BIT #26 (32)	22	W-G
	13	J11-16	2	BIT #25 Y_1 (16)	22	W-BL
	14	J11-17	2	BIT #24 (8)	22	W-V
	15	J11-18	2	BIT #23 (4)	22	W-S
	16	J11-19	2	BIT #22 (2)	22	W
	17	J11-20	2	BIT #21 (1)	22	W-BK
	18			Chassis Ground		
	19			Chassis Ground		
	20			Chassis Ground		
	21					
	22					
	23					
	24					
	25					

NOTES:

J8

Y_1 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33	+ Ref-5	1	+ Ref. Voltage	20	W-R
	34			Chassis Ground		
	35	J4-34	Direct	Input Amp "B"	Coax	
	36			Chassis Ground		
	37	J4-6	1	Output Amp "B"	20	BL
	38	J18-A	1	Output Amp "B" (Y_1 Output)	20	BL
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47	-20-5	4	-20V	20	S
	48					
	49	-70-3	4	-70V	20	W-BK
	50					

NOTES:

J8

Y_1 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	37					
	38					
	6					
	7					

NOTES: JUMPER CONNECTIONS

J9
X_2 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	Frame		Chassis Ground	22	BK
	2	J5-1	Direct	Input Amp "A"	Coax	
	3			Chassis Ground		
	4	J5-4	1	Output Amp "A"	22	V
	5					
	6	J8-6	2	Holding Relay Signal	22	W-Y
	7	J10-7	2	Holding Relay Signal	22	W-Y
	8	J12-1	2	BIT #20 X_2 (512)	22	W-BR
	9	J12-2	2	BIT #19 X_2 (256)	22	W-R
	10	J12-3	2	BIT #18 X_2 (128)	22	W-O
	11	J12-4	2	BIT #17 X_2 (64)	22	W-Y
	12	J12-5	2	BIT #16 X_2 (32)	22	W-G
	13	J12-6	2	BIT #15 X_2 (16)	22	W-BL
	14	J12-7	2	BIT #14 X_2 (8)	22	W-V
	15	J12-8	2	BIT #13 X_2 (4)	22	W-S
	16	J12-9	2	BIT #12 X_2 (2)	22	W
	17	J12-10	2	BIT #11 X_2 (1)	22	W-BK
	18			Chassis Ground		
	19			Chassis Ground		
	20			Chassis Ground		
	21					
	22					
	23					
	24					
	25					

NOTES:

J9
X_2 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33	+ Ref-6	1	+ Ref. Voltage	20	W-R
	34			Chassis Ground		
	35	J5-34	Direct	Input Amp "B"	Coax	
	36			Chassis Ground		
	37	J5-6	1	Output Amp "B"	20	S
	38	J18-X	1	Output Amp "B" (X_2 Output)	20	S
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47	-20-6	4	-20V	20	S
	48					
	49	-70-4	4	-70V	20	W-BK
	50					

NOTES:

J9
X_2 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	37					
	38					
	6					
	7					

NOTES: JUMPER CONNECTIONS

J10
Y_2 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	Frame		Chassis Ground	22	BK
	2	J6-1	Direct	Input Amp "A"	Coax	
	3			Chassis Ground		
	4	J6-4	1	Output Amp "A"	22	W
	5					
	6	J13-16	2	Holding Relay Signal	22	W-Y
	7	J9-7	2	Holding Relay Signal	22	W-Y
	8	J12-11	2	BIT #10 Y_2 (512)	22	W-BR
	9	J12-12	2	BIT #9 Y_2 (256)	22	W-R
	10	J12-13	2	BIT #8 Y_2 (128)	22	W-O
	11	J12-14	2	BIT #7 Y_2 (64)	22	W-Y
	12	J12-15	2	BIT #6 Y_2 (32)	22	W-G
	13	J12-16	2	BIT #5 Y_2 (16)	22	W-BL
	14	J12-17	2	BIT #4 Y_2 (8)	22	W-V
	15	J12-18	2	BIT #3 Y_2 (4)	22	W-S
	16	J12-19	2	BIT #2 Y_2 (2)	22	W
	17	J12-20	2	BIT #1 Y_2 (1)	22	W-BK
	18			Chassis Ground		
	19			Chassis Ground		
	20			Chassis Ground		
	21					
	22					
	23					
	24					
	25					

NOTES:

J10
Y_2 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33	+ Ref-7	1	+ Ref. Voltage	20	W-R
	34			Chassis Ground		
	35	J6-34	Direct	Input Amp "B"	Coax	
	36			Chassis Ground		
	37	J6-6	1	Output Amp "B"	20	W-BL
	38	J18-R	1	Output Amp "B" (Y_2 Output)	20	W-BL
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47	-20-7	4	-20V	20	S
	48					
	49	-70-5	4	-70V	20	W-BK
	50					

NOTES:

J10
Y_2 DATA SUMMING

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	37–38					
	6–7					

NOTES: JUMPER CONNECTIONS

J11

S.R. #1

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J7-8	2	Output F/F #1 Bit #(40)	22	W-BR
	2	J7-9	↑	Output F/F #2 (39)	↑	W-R
	3	J7-10		Output F/F #3 (38)		W-O
	4	J7-11		Output F/F #4 (37)		W-Y
	5	J7-12		Output F/F #5 (36)		W-G
	6	J7-13		Output F/F #6 (35)		W-BL
	7	J7-14		Output F/F #7 (34)		W-V
	8	J7-15		Output F/F #8 (33)		W-S
	9	J7-16		Output F/F #9 (32)		W
	10	J7-17		Output F/F #10 (31)		W-BK
	11	J8-8		Output F/F #11 (30)		W-BR
	12	J8-9		Output F/F #12 (29)		W-R
	13	J8-10		Output F/F #13 (28)		W-O
	14	J8-11		Output F/F #14 (27)		W-Y
	15	J8-12		Output F/F #15 (26)		W-G
	16	J8-13		Output F/F #16 (25)		W-BL
	17	J8-14		Output F/F #17 (24)		W-V
	18	J8-15		Output F/F #18 (23)		W-S
	19	J8-16	↓	Output F/F #19 (22)	↓	W
	20	J8-17	2	Output F/F #20 (21)	22	W-BK
	21					
	22					
	23					
	24					
	25					

NOTES:

J11

S.R. #1

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34	J12-35	2	Core Shift Trigger	22	W-V
	35					
	36	J12-37	2	F/F Reset Trigger	22	G
	37					
	38	J12-39	2	Read Gate Trigger	22	W-G
	39					
	40					
	41	J13-14	2	Core Input	22	W-O
	42	J12-41	2	Core Output	22	O
	43					
	44	+12-3	4	+12V	20	R
	45	OV-5	4	OV	20	BK
	46	OV-6	4	OV	20	BK
	47	-20-8	4	-20V	20	S
	48	-20-9	4	-20V	20	S
	49					
	50	Frame		Chassis Ground	22	BK

NOTES:

J12

S.R. #2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J9-8	2	Output F/F #1 Bit #(20)	22	W-BR
	2	J9-9		Output F/F #2 (19)		W-R
	3	J9-10		Output F/F #3 (18)		W-O
	4	J9-11		Output F/F #4 (17)		W-Y
	5	J9-12		Output F/F #5 (16)		W-G
	6	J9-13		Output F/F #6 (15)		W-BL
	7	J9-14		Output F/F #7 (14)		W-V
	8	J9-15		Output F/F #8 (13)		W-S
	9	J9-16		Output F/F #9 (12)		W
	10	J9-17		Output F/F #10 (11)		W-BK
	11	J10-8		Output F/F #11 (10)		W-BR
	12	J10-9		Output F/F #12 (9)		W-R
	13	J10-10		Output F/F #13 (8)		W-O
	14	J10-11		Output F/F #14 (7)		W-Y
	15	J10-12		Output F/F #15 (6)		W-G
	16	J10-13		Output F/F #16 (5)		W-BL
	17	J10-14		Output F/F #17 (4)		W-V
	18	J10-15		Output F/F #18 (3)		W-S
	19	J10-16		Output F/F #19 (2)		W
	20	J10-17	2	Output F/F #20 (1)	22	W-BK
	21					
	22					
	23					
	24					
	25					

NOTES:

J12

S.R. # 2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34	J13-12	2	Core Shift Trigger	22	W-V
	35	J11-34	2	Core Shift Trigger	22	W-V
	36	J13-7	2	F/F Reset Trigger	22	G
	37	J11-36	2	F/F Reset Trigger	22	G
	38	J13-8	2	Read Gate Trigger	22	W-G
	39	J11-38	2	Read Gate Trigger	22	W-G
	40					
	41	J11-42	2	Core Input	22	O
	42			Core Output		
	43					
	44	+12-4	4	+12V	20	R
	45	OV-7	4	OV	20	BK
	46	OV-8	4	OV	20	BK
	47	-20-10	4	-20V	20	S
	48	-20-11	4	-20V	20	S
	49					
	50	Frame		Chassis Ground	22	BK

NOTES:

J12

S.R. #2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	34					
	35					
	36					
	37					
	38					
	39					

NOTES: JUMPER CONNECTIONS

J13
CONTROL
(DIGITAL CONNECTOR)

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J20-H	2	Select and Ready	Coax	
	2					
	3	J20-A	2	Data	Coax	
	4					
	5	J20-B	2	Sample	Coax	
	6					
	7	J12-36	2	Reset Trigger	22	G
	8	J12-38	2	Read Gate Trigger	22	W-G
	9					
	10	J20-J	2	D/A Ready	Coax	
	11					
	12	J12-34	2	Core Driver Trigger	22	W-V
	13					
	14	J11-41	2	Shift Register Serial Input	22	W-O
	15					
	16	J10-6	2	Holding Relay Signal	22	W-Y
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES:

J13
CONTROL
(DIGITAL CONNECTOR)

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43	+12-5	4	+12V	20	R
	44			+12V		
	45	0V-9	4	0V	20	BK
	46	0V-10	4	0V	20	BK
	47	-20-12	4	-20V	20	S
	48	-20-13	4	-20V	20	S
	49	-70-6	4	-70V	20	W-BK
	50	Frame		Chassis Ground	22	BK

NOTES:

J14
CONTROL
(ANALOG CONNECTOR)

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1			Chassis Ground		
	2	J16-1	1	Amp #1 Input	Coax	
	3			Chassis Ground		
	4	-Ref-2	1	-Ref. Output	20	W-V
	5			-Ref. Output		
	6					
	7	± -5	3	±	22	BK
	8			±		
	9					
	10	J18-Z	1	+Ext. Ref. Input	Coax	
	11					
	12	+250-2	3	+250V	22	R
	13			+250V		
	14					
	15	-250-3	3	-250V	22	W
	16					
	17	-560-2	3	-560V	22	V
	18			Chassis Ground		
	19			Chassis Ground		
	20			Chassis Ground		
	21	H.Q.-2	1	H.Q. Ground	20	BK
	22					
	23					
	24					
	25					

NOTES:

J14
CONTROL
(ANALOG CONNECTOR)

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29	J1-33	3	120VAC $\emptyset_2$ Switched	18	W-S
	30	J17-4	3	120VAC $\emptyset_2$ Switched	18	W-S
	31					
	32	J1-36	3	120VAC $\emptyset_1$ Switched	18	S
	33	BL-1	3	120VAC $\emptyset_1$ Switched	18*	S
	34			Chassis Ground		
	35	J16-34	1	Amp #2 Input	Coax	
	36			Chassis Ground		
	37	+Ref-2	1	+Ref. Output	20	W-R
	38			+Ref Output		
	39					
	40	J15-30	3	Chopper Drive (Hot)	22	W-BR
	41	J19-B	3	120VAC Common	18	W
	42	BL-2	3	120VAC Common	18*	W
	43					
	44	XF2-2	3	120VAC $\emptyset_2$ (Fused)	18	W-S
	45	XF2-2	3	120VAC $\emptyset_2$ (Fused)	18	W-S
	46					
	47	XF1-2	3	120VAC $\emptyset_1$ (Fused)	18	S
	48	XF1-2	3	120VAC $\emptyset_1$ (Fused)	18	S
	49					
	50	Frame		Chassis Ground	22	BK

NOTES: *Twisted Pair

J14
CONTROL
(ANALOG CONNECTOR)

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	29					
	30					
	32					
	33					
	41					
	42					
	44					
	45					
	47					
	48					

NOTES:
JUMPER CONNECTIONS

J15
CHOPPER DRIVE

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES:

J15
CHOPPER DRIVE

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30	J14-40	3	Chopper Drive (Hot)	22	W-BR
	31					
	32					
	33					
	34					
	35					
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43					
	44	+12-2	4	+12V	20	R
	45	0V-3	4	0V	20	BK
	46	J16-43	3	0V (Chopper Drive Gnd)	22'	W-BR
	47	J16-41	3	Chopper Drive (Hot)	22'	BR
	48	-20-3	4	-20V	20	S
	48					
	49					
	50					

NOTES: (') Twisted Pair

J15
CHOPPER DRIVE

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	30–47					
	45–46					

NOTES: **JUMPER CONNECTIONS**

J16
REF DC AMPS #1 and #2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J14-2	1	Input, Amp A (#1)	Coax	
	2			H.Q. Ground		
	3					
	4	-Ref-1	1	Output, Amp A (#1)	20	W-V
	5			Boost, Amp A		
	6	+Ref-1	1	Output, Amp B (#2)	20	W-R
	7			Boost, Amp B		
	8					
	9	-560-3	3	-560V	22	V
	10			-560V		
	11					
	12	+250-3	3	+250V	22	R
	13			+250V		
	14	J2-9	3	Fil #1A	20*	W-BR
	15			Fil #1A		
	16	J2-42	3	Fil #1B	20*	BR
	17			Fil #1B		
	18	H.Q.-3	1	H.Q. Ground	20	BK
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES: (*) Twisted Pair

J16
REF DC AMPS #1 and #2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34	J14-35	1	Input, Amp B (#2)	Coax	
	35	Frame		Chassis Ground	22	BK
	36			Overload, Amp B		
	37	± -6	3	±	22	BK
	38			Overload, Amp A		
	39	-250-4	3	-250V	22	W
	40			-250V		
	41	J15-47	3	Chopper Drive (Hot)	22'	BR
	42	J6-42	3	Choper Drive (Hot)	22"	BR
	43	J15-46	3	Chopper Drive (Gnd)	22'	W-BR
	44	J6-44	3	Chopper Drive (Gnd	22"	W-BR
	45	J1-9	3	Fil #2A	20*	W-BR
	46			Fil #2A		
	47	J1-26	3	Fil #2CT (-125V)	20*	W
	48			Fil #2CT (-125V)		
	49	J1-42	3	Fil #2B	20*	BR
	50			Fil #2B		

NOTES: (*) Twisted Triple
(') Twisted Pair
(") Twisted Pair

J16
REF DC AMPS #1 and #2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	2					
	18					
	9					
	10					
	12					
	13					
	14					
	15					
	16					
	17					
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43					
	44					
	45					
	46					
	47					
	48					
	49					
	50					

NOTES:
JUMPER CONNECTIONS

J17
-70V, -20V, +12V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J19-B	3	120VAC Common	18	W
	2			120VAC Common		
	3					
	4	J14-30	3	120VAC $\emptyset_2$ Switched	18	W-S
	5			120VAC $\emptyset_2$ Switched		
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
	25					

NOTES:

J17
-70V, -20V, +12V
POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	26					
	27					
	28					
	29					
	30					
	31					
	32					
	33					
	34			+12V Unreg. Output		
	35			-20V Unreg. Output		
	36					
	37					
	38					
	39					
	40					
	41					
	42					
	43					
	44	+12-1	4	+12V	20	R
	45	0V-1	4	0V	20	BK
	46	0V-2	4	0V	20	BK
	47	-20-1	4	-20V	20	S
	48	-20-2	4	-20V	20	S
	49	-70-1	4	-70V	20	W-BK
	50	Frame		Chassis Ground	22	BK

NOTES:

J17 -70V, -20V, +12V POWER SUPPLY

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1 ┐					
	2 ┘					
	4 ┐					
	5 ┘					

NOTES: JUMPER CONNECTIONS

J18 ANALOG CONNECTOR

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	A	J8-38	1	Y_1 Analog Output	20	BL
	B					
	C					
	D	-Ref-3	1	-Ref. Voltage Output	20	W-V
	E					
	F					
	G	H.Q. -1	1	H.Q. Ground	20	BK
	H					
	J					
	K	+Ref-3	1	+Ref. Voltage Output	20	W-R
	L					
	M					
	N	J7-38	1	X_1 Analog Output	20	Y
	P					
	R	J10-38	1	Y_2 Analog Output	20	W-BL
	S					
	T					
	U					
	V					
	W					
	X	J9-38	1	X_2 Analog Output	20	S
	Y					
	Z	J14-10	1	+Ext. Ref. Voltage Input	Coax	

NOTES: AN3102A-32-13S

J19
AC CONNECTOR

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	A	S1-3	*	120VAC $\emptyset_1$ Input	14	S
	E	S1-6	*	120VAC $\emptyset_2$ Input	14	W-S
	B	J14-41	3	120VAC Common	18	W
	B	J1-1	3	120VAC Common	18	W
	B	J17-1	3	120VAC Common	18	W
	B	DS2-B	3	120VAC Common	22	W
	C	Frame		Frame Ground	16	BK
	D					

NOTES:
* Do not cable.
AN3102A-18-11P

J20
DIGITAL CONNECTOR

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	A	J13-3	2	Data	Coax	
	B	J13-5	2	Sample	Coax	
	C					
	D					
	E	OV-4	2	OV	20	BK
	F					
	G					
	H	J13-1	2	Select and Ready	Coax	
	J	J13-10	2	D/A Ready	Coax	

NOTES:
AN3102A-22-17P

-560V BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J1-17	3	-560V	20	V
	2	J14-17	3	-560V	22	V
	3	J16-9	3	-560V	22	V
	4	J3-9	3	-560V	22	V
	5	J4-9	3	-560V	22	V
	6	J5-9	3	-560V	22	V
	7	J6-9	3	-560V	22	V
	8					
	9	-250V-9		(3) 100K 2 Watt Resistors		
	10					

NOTES:

-250V BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J1-13	3	-250V	20	W
	2	J2-16	3	-250V	20	W
	3	J14-15	3	-250V	22	W
	4	J16-39	3	-250V	22	W
	5	J3-39	3	-250V	22	W
	6	J4-39	3	-250V	22	W
	7	J5-39	3	-250V	22	W
	8	J6-39	3	-250V	22	W
	9	-560V-9		(3) 100K 2 watt Resistors		
	10					

NOTES:

± BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	Frame	3	±	18	BK
	1	0V-11	Direct		18	BK
	2	J1-47	3	±	20	BK
	3	J2-13	3	±	20	BK
	4	J2-26	3	±	20	BK
	5	J14-7	3	±	22	BK
	6	J16-37	3	±	22	BK
	7	J3-37	3	±	22	BK
	8	J4-37	3	±	22	BK
	9	J5-37	3	±	22	BK
	10	J6-37	3	±	22	BK
	11					
	12					
	13					
	14					
	15					

NOTES:

+250V BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J2-47	3	+250V	20	R
	2	J14-12	3	+250V	22	R
	3	J16-12	3	+250V	22	R
	4	J3-12	3	+250V	22	R
	5	J4-12	3	+250V	22	R
	6	J5-12	3	+250V	22	R
	7	J6-12	3	+250V	22	R
	8					
	9					
	10					

NOTES:

-REF BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J16-4	1	-Ref Output	20	W-V
	2	J14-4	1	-Ref Output	20	W-V
	3	J18-D	1	-Ref Output	20	W-V
	4					
	5					
	6					
	7					
	8					
	9					
	10					

NOTES:

H.Q. GROUND BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J18-6	1	H.Q. Ground	20	BK
	2	J14-21	1	H.Q. Ground	20	BK
	3	J16-18	1	H.Q. Ground	20	BK
	4	J3-18	1	H.Q. Ground	20	BK
	5	J4-18	1	H.Q. Ground	20	BK
	6	J5-18	1	H.Q. Ground	20	BK
	7	J6-18	1	H.Q. Ground	20	BK
	8					
	9					
	10					

NOTES:

+REF BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J16-6	1	+Ref Output	20	W-R
	2	J14-37	1	+Ref Output	20	W-R
	3	J18-K	1	+Ref Output	20	W-R
	4	J7-33	1	+Ref Output	20	W-R
	5	J8-33	1	+Ref Output	20	W-R
	6	J9-33	1	+Ref Output	20	W-R
	7	J10-33	1	+Ref Output	20	W-R
	8					
	9					
	10					

NOTES:

-70V BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J17-49	4	-70V	20	W-BK
	2	J7-49				
	3	J8-49				
	4	J9-49				
	5	J10-49				
	6	J13-49	4	-70V	20	W-BK
	7					
	8					
	9					
	10					

NOTES:

-20V BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J17-47	4	-20V	20	S
	2	J17-48				
	3	J15-48				
	4	J7-47				
	5	J8-47				
	6	J9-47				
	7	J10-47				
	8	J11-47				
	9	J11-48				
	10	J12-47				
	11	J12-48				
	12	J13-47				
	13	J13-48	4	-20V	20	S
	14					
	15					

NOTES:

0V BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J17-45	4	0V	20	BK
	2	J17-46	4			
	3	J15-45	4			
	4	J20-E	2			
	5	J11-45	4			
	6	J11-46	4			
	7	J12-45				
	8	J12-46	4			
	9	J13-45	4			
	10	J13-46	4	0V	20	
	11	±-1	Direct		18	BK

NOTES:

+12V BUS

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1	J17-44	4	+12V	20	R
	2	J15-44	4	+12V	20	R
	3	J11-44	4	+12V	20	R
	4	J12-44	4	+12V	20	R
	5	J13-43	4	+12V	20	R
	6					
	7					
	8					
	9					
	10					

NOTES:

BL BLOWER

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	BL-1	J14-33	3	120VAC $\emptyset_1$ Switched	18*	S
	BL-2	J14-42	3	120VAC Common	18*	W

NOTES: *Twisted Pair

POWER INDICATORS
DS1, DS2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	DS1-A	R1-2	Direct	Power Indicator Voltage		
	DS1-B	DS2-B	Direct	120V AC Common	22	W
	DS2-A	R2-2	Direct	Power Indicator Voltage		
	DS2-B	J19-B	3	120V AC Common	22	W
	DS2-B	DS1-B	Direct	120V AC Common	22	W

NOTES:

INDICATOR RESISTORS
R1, R2

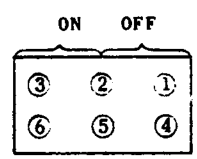
WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	R1-1	XF1-2	Direct	120V AC $\emptyset_1$ (Fused)		
	R1-2	DS1-A	Direct	Power Indicator Voltage		
	R2-1	XF2-2	Direct	120V AC $\emptyset_2$ (Fused)		
	R2-2	DS2-A	Direct	Power Indicator Voltage		

NOTES:

AC POWER SWITCH

S1

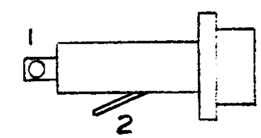
WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	1					
	2	XF1-1	*	120V AC $Ø_1$ Input	14	S
	3	J19-A	*	120V AC $Ø_1$ Input	14	S
	4					
	5	XF2-1	*	120V AC $Ø_2$ Input	14	W-S
	6	J19-E	*	120V AC $Ø_2$ Input	14	W-S



NOTES: * Do not cable.

FUSES
XF1, XF2

WIRE NO.	TERMINAL	DESTINATION	CABLE	IDENTIFICATION	WIRE SIZE	COLOR
	XF1-1	S1-2	*	120VAC $Ø_1$ Input	14	S
	XF1-2	J14-47	3	120VAC $Ø_1$ (Fused)	18	S
	XF1-2	R1-1	Direct	120VAC $Ø_1$ (Fused)		
	XF1-2	J14-48	3	120VAC $Ø_1$ (Fused)	18	S
	XF2-1	S1-5	*	120VAC $Ø_2$ Input	14	W-S
	XF2-2	J14-44	3	120VAC $Ø_2$ (Fused)	18	W-S
	XF2-2	R2-1	Direct	120VAC $Ø_2$ (Fused)		
	XF2-2	J14-45	3	120VAC $Ø_2$ (Fused)	18	W-S



NOTES: * Do not cable

CHAPTER IX

SCHEMATICS AND DIAGRAMS

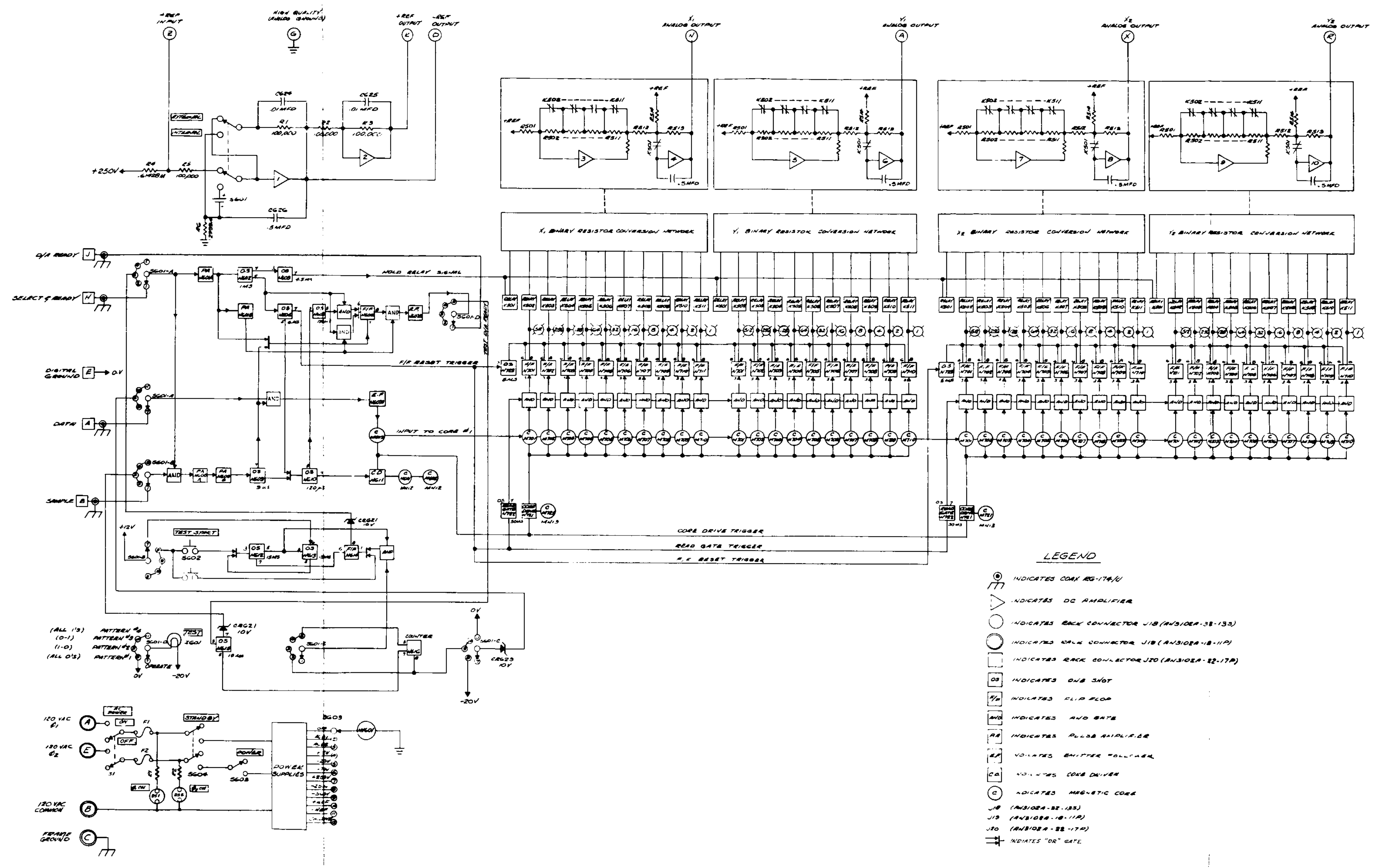


Figure 9-1. Block Diagram
MEC Model 1576 D-A Converter
Dwg. #1576B1A

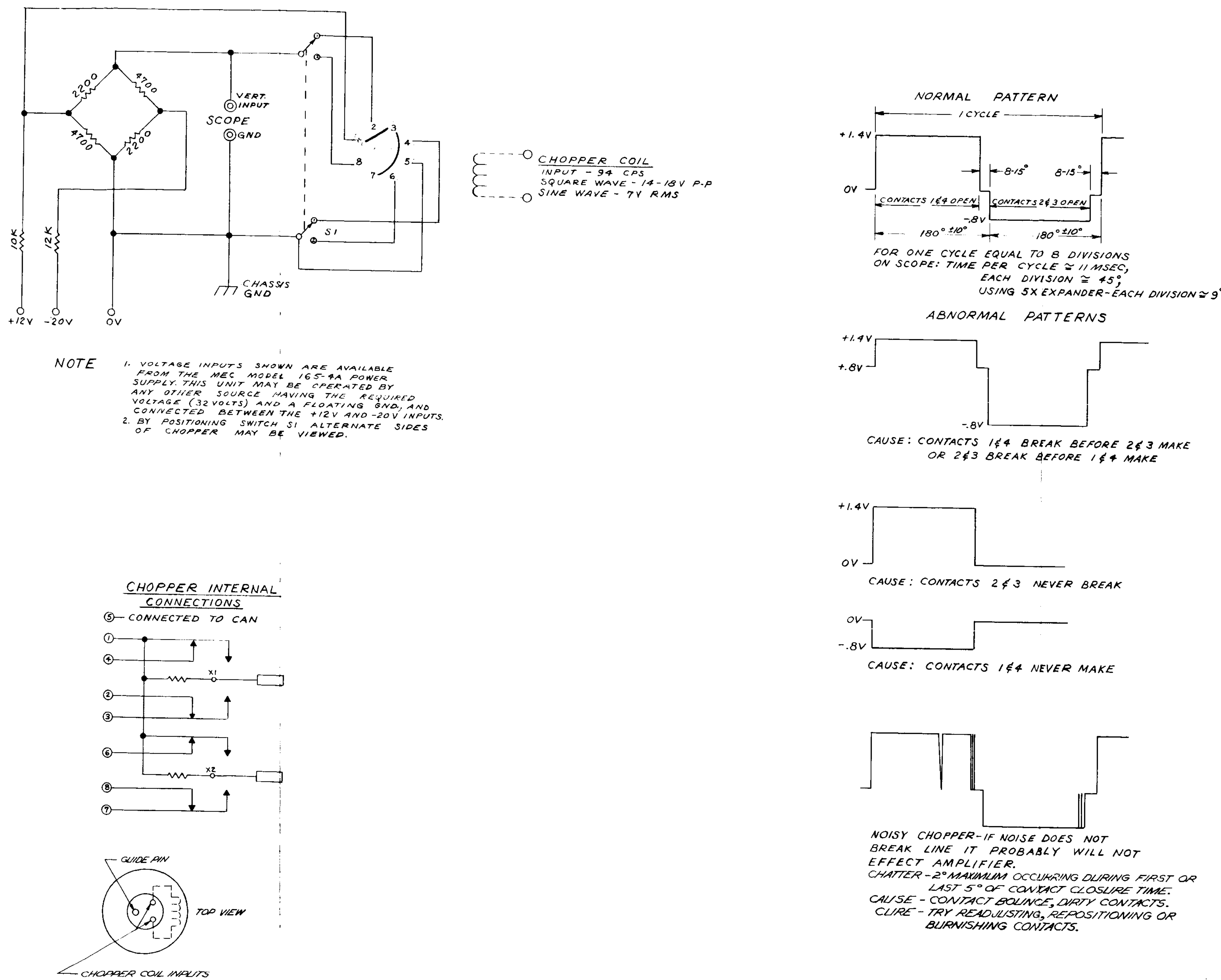


Figure 9-2 Schematic
Mechanical Converter Test Set
Dwg. #63S4BX

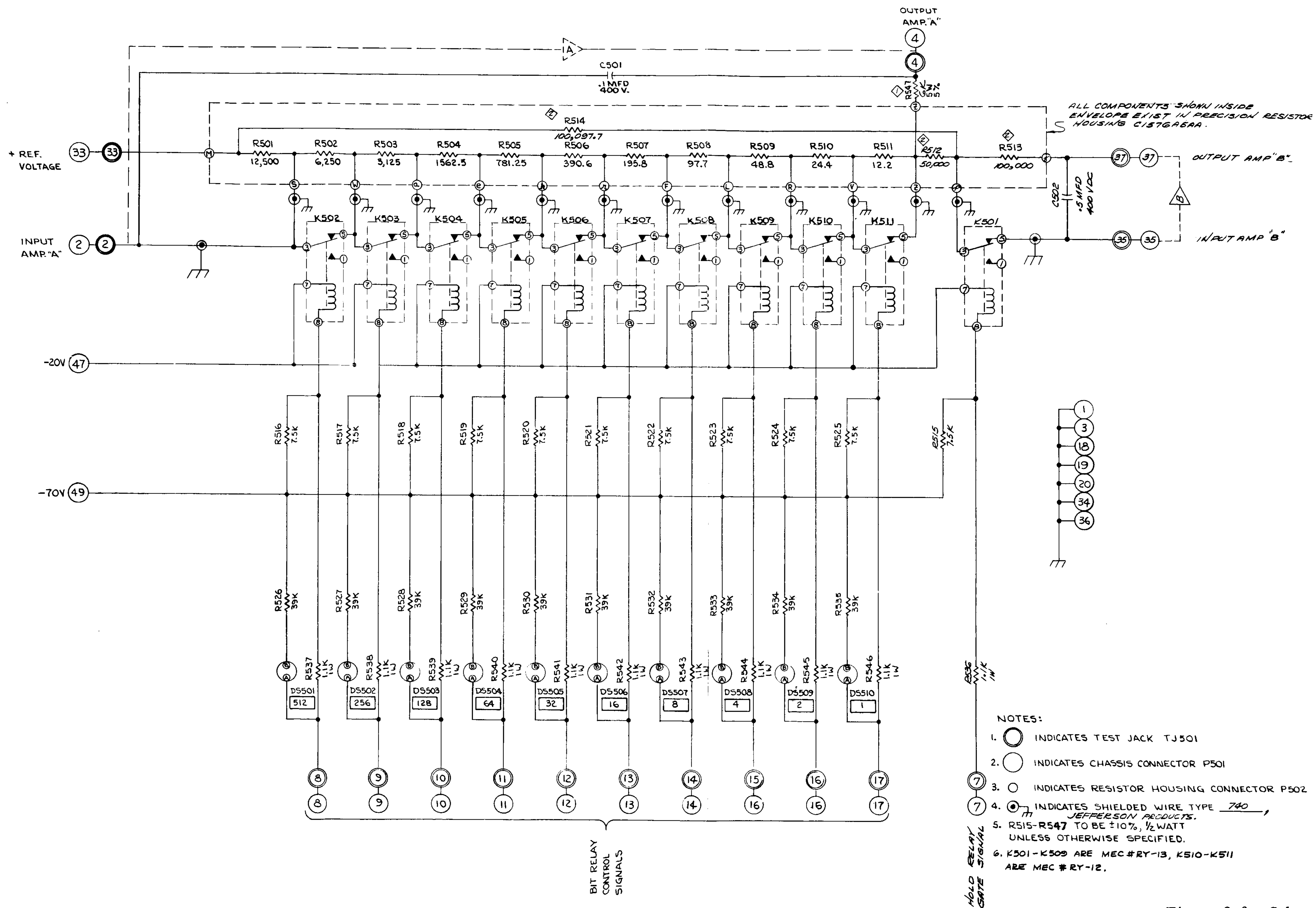
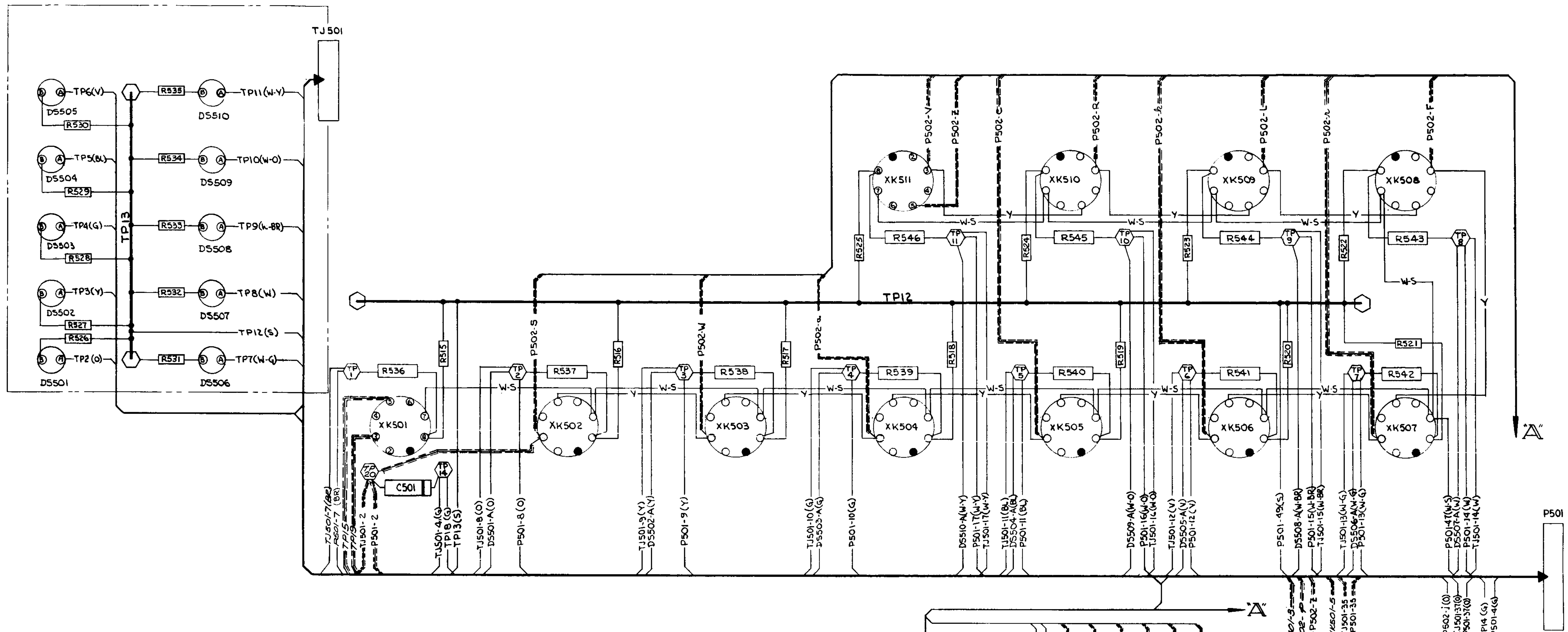
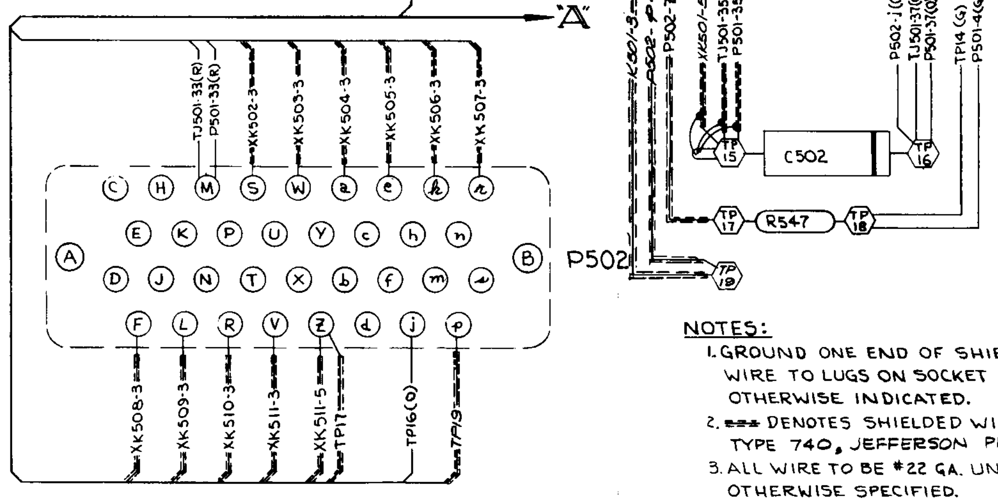


Figure 9-3. Schematic
Data Summing Chassis
Dwg. #1576S5A





P501

PIN	DESTINATION	WIRE SIZE & COLOR	FUNCTION	PIN	DESTINATION	WIRE SIZE & COLOR	FUNCTION	PIN	DESTINATION	WIRE SIZE & COLOR	FUNCTION
1	GND. LUG	(BK) 20	CHASSIS GND	18			CHASSIS GND.	34			CHASSIS GND.
2	TP20	SHIELDED	IN. AMP. "A"	19			CHASSIS GND.	35	TP15	SHIELDED	IN. AMP. "B"
3			CHASSIS GND	20			CHASSIS GND.	36			CHASSIS GND.
4	TP18	G	OUT. AMP. "A"	21				37	TP16	O	OUT. AMP. "B"
5				22				38			
6				23				39			
7	TP1	BR	HOLDING RELAY GATE SIGNAL	24				40			
8	TP2	O	RELAY CONT. SIG.	25				41			
9	TP3	Y	RELAY CONT. SIG.	26				42			
10	TP4	G	RELAY CONT. SIG.	27				43			
11	TP5	BL	RELAY CONT. SIG.	28				44			
12	TP6	V	RELAY CONT. SIG.	29				45			
13	TP7	W-G	RELAY CONT. SIG.	30				46			
14	TP8	W	RELAY CONT. SIG.	31				47	XK507-7	W-S	-20V.
15	TP9	W-BR	RELAY CONT. SIG.	32				48			
16	TP10	W-O	RELAY CONT. SIG.	33	P502-M	R	+REF.	49	TP12	S	-70V.
17	TP11	W-Y	RELAY CONT. SIG.					50			

NOTE (P501)
1. JUMPER TERMINALS 1, 3, 18, 19, 20, 34, 36.

TJ501

PIN	DESTINATION	WIRE SIZE & COLOR	FUNCTION	PIN	DESTINATION	WIRE SIZE & COLOR	FUNCTION	PIN	DESTINATION	WIRE SIZE & COLOR	FUNCTION
1				18				34			
2	TP20	SHIELDED	IN. AMP. "A"	19				35	TP15	SHIELDED	IN. AMP. "B"
3				20				36			
4	TP14	G	OUT. AMP "A"	21				37	TP16	O	OUT. AMP "B"
5				22				38			
6				23				39			
7	TP1	BR	HOLDING RELAY GATE SIGNAL	24				40			
8	TP2	O	RELAY CONT. SIG.	25				41			
9	TP3	Y	RELAY CONT. SIG.	26				42			
10	TP4	G	RELAY CONT. SIG.	27				43			
11	TP5	BL	RELAY CONT. SIG.	28				44			
12	TP6	V	RELAY CONT. SIG.	29				45			
13	TP7	W-G	RELAY CONT. SIG.	30				46			
14	TP8	W	RELAY CONT. SIG.	31				47			
15	TP9	W-BR	RELAY CONT. SIG.	32				48			
16	TP10	W-O	RELAY CONT. SIG.	33	P502-M	R	+REF	49			
17	TP11	W-Y	RELAY CONT. SIG.					50			

NOTES:
1. GROUND ONE END OF SHIELDED WIRE TO LUGS ON SOCKET UNLESS OTHERWISE INDICATED.
2. ═══ DENOTES SHIELDED WIRE TYPE 740, JEFFERSON PRODUCTS
3. ALL WIRE TO BE #22 GA. UNLESS OTHERWISE SPECIFIED.

Figure 9-4. Wiring Diagram Data Summing Chassis Dwg. #1576W5A

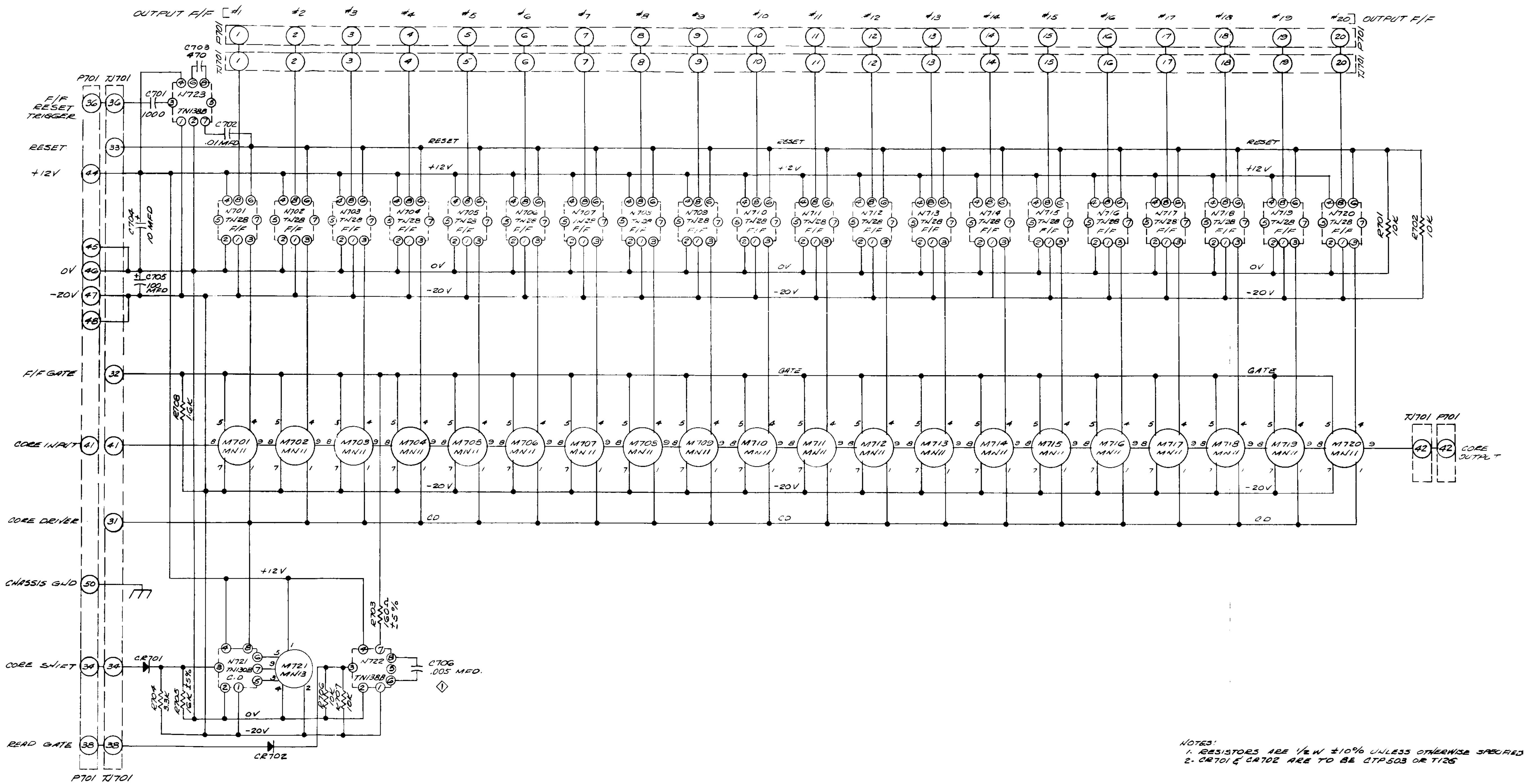
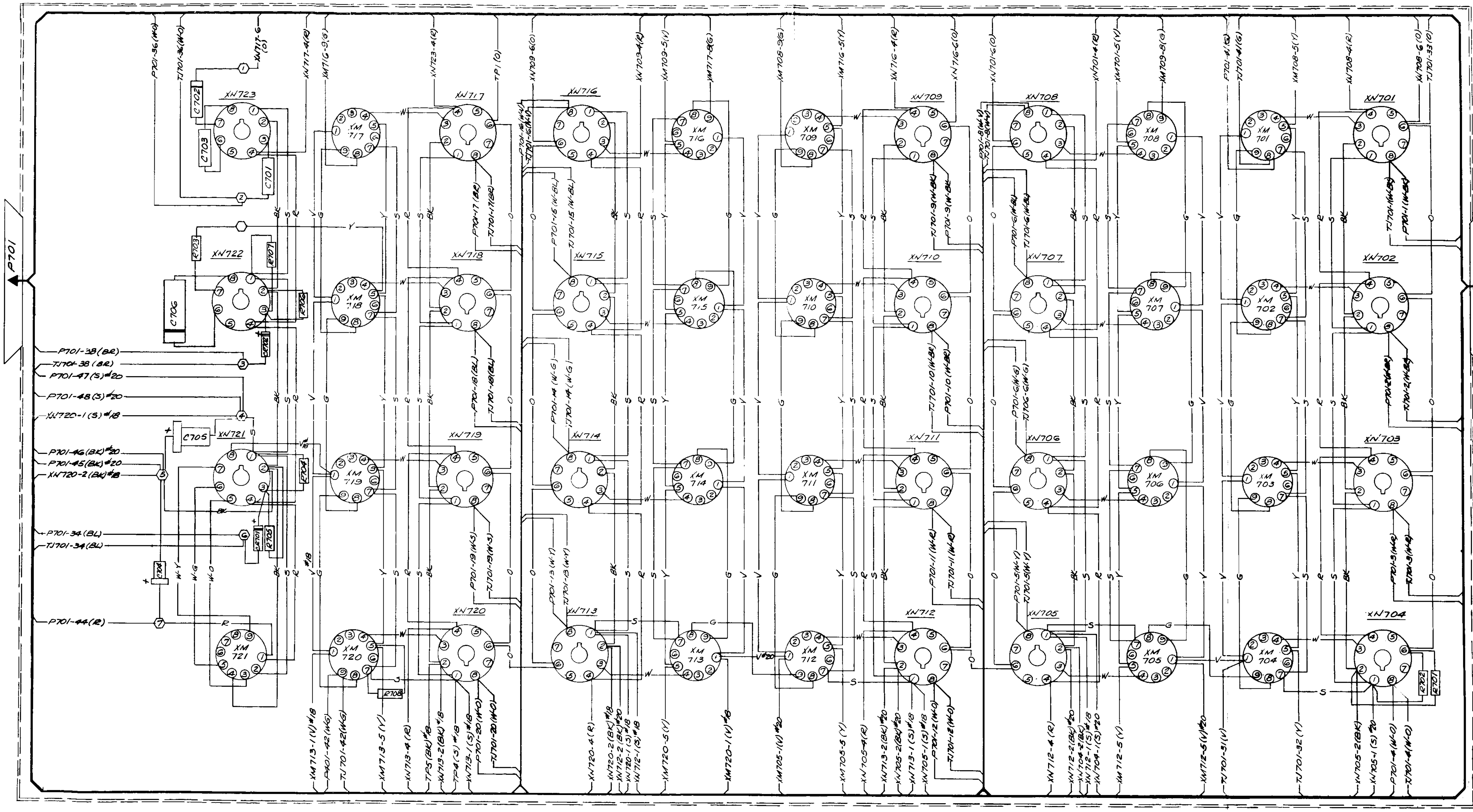


Figure 9-5. Schematic
20 Bit Shift Register
Dwg. #1576S7A

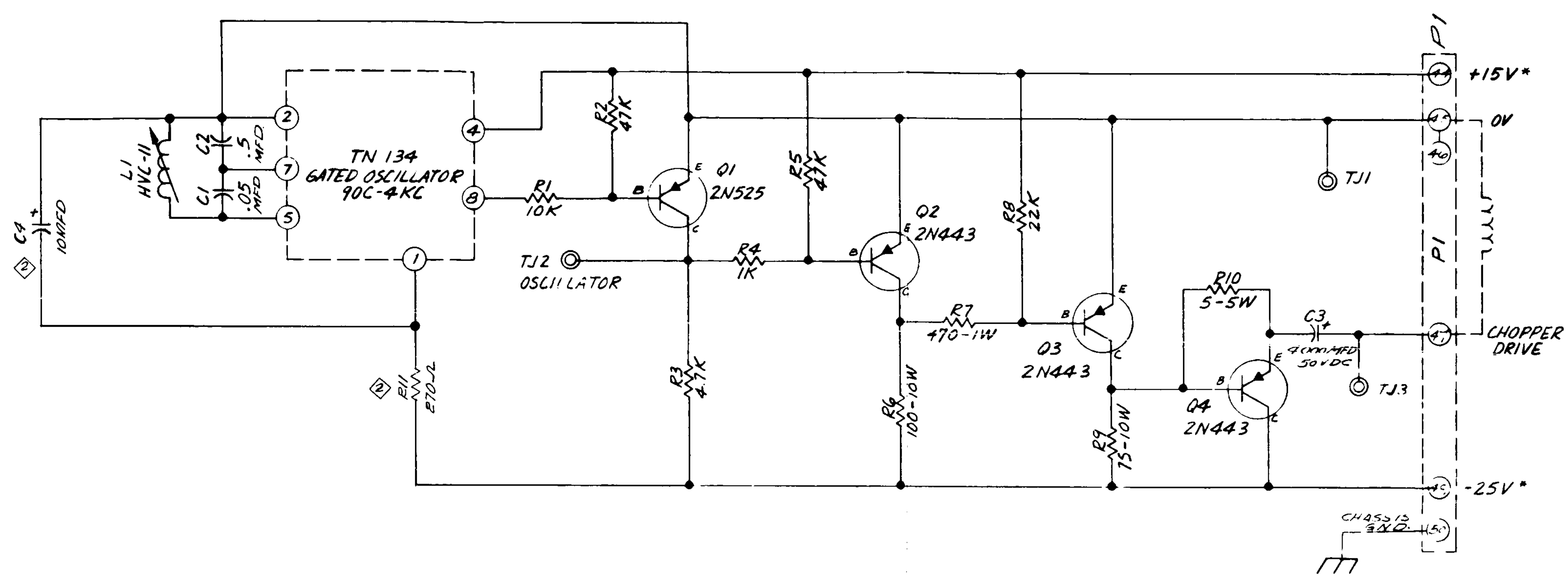


P701											
PIN	DEST.	FUNCTION	WIRE	PIN	DEST.	FUNCTION	WIRE	PIN	DEST.	FUNCTION	WIRE
1	XN701-8	OUTPUT F/F #1	W-BK	18	XN718-8	OUTPUT F/F #18	BL	34	TP6	CORE SHIFT	BL
2	XN702-8	#2	W-BR	19	XN719-8	#19	W-S	35			
3	XN703-8	#3	W-R	20	XN720-8	#20	W-O	36	TP2	F/F RESET TRIG	W-V
4	XN704-8	#4	W-O	21				37			
5	XN705-8	#5	W-Y	22				38	TP3	READ GATE	BR
6	XN706-8	#6	W-G	23				39			
7	XN707-8	#7	W-BL	24				40			
8	XN708-8	#8	W-V	25				41	XM701-8	CORE INPUT	G
9	XN709-8	#9	W-BK	26				42	XM720-9	CORE OUTPUT	W-G
10	XN710-8	#10	W-BR	27				43			
11	XN711-8	#11	W-R	28				44	TP7	+12 V	R
12	XN712-8	#12	W-O	29				45	TP5	0 V	BK #20
13	XN713-8	#13	W-Y	30				46	TP5	0 V	BK #20
14	XN714-8	#14	W-G	31				47	TP4	-20V	S #20
15	XN715-8	#15	W-BL	32				48	TP4	-20V	S #20
16	XN716-8	#16	W-V	33				49			
17	XN717-8	#17	BR					50	GND LUG	CHASSIS GND	BK

TJ701											
PIN	DEST.	FUNCTION	WIRE	PIN	DEST.	FUNCTION	WIRE	PIN	DEST.	FUNCTION	WIRE
1	XN701-8	OUTPUT F/F #1	W-BK	18	XN718-8	OUTPUT F/F #18	BL	34	TP6	CORE SHIFT	BL
2	XN702-8	#2	W-BR	19	XN719-8	#19	W-S	35			
3	XN703-8	#3	W-R	20	XN720-8	#20	W-O	36	TP2	F/F RESET TRIG	W-V
4	XN704-8	#4	W-O	21				37			
5	XN705-8	#5	W-Y	22				38	TP3	READ GATE	BR
6	XN706-8	#6	W-G	23				39			
7	XN707-8	#7	W-BL	24				40			
8	XN708-8	#8	W-V	25				41	XM701-8	CORE INPUT	G
9	XN709-8	#9	W-BK	26				42	XM720-9	CORE OUTPUT	W-G
10	XN710-8	#10	W-BR	27				43			
11	XN711-8	#11	W-R	28				44			
12	XN712-8	#12	W-O	29				45			
13	XN713-8	#13	W-Y	30				46			
14	XN714-8	#14	W-G	31	XM704-1	CORE DRIVE	V	47			
15	XN715-8	#15	W-BL	32	XM704-5	F/F GATE	Y	48			
16	XN716-8	#16	W-V	33	XN701-6	RESET	O	49			
17	XN717-8	#17	BR					50			

NOTE:
1. ALL WIRE TO BE #22 GA UNLESS OTHERWISE SPECIFIED.
2. ⬡ INDICATES TIE POINT

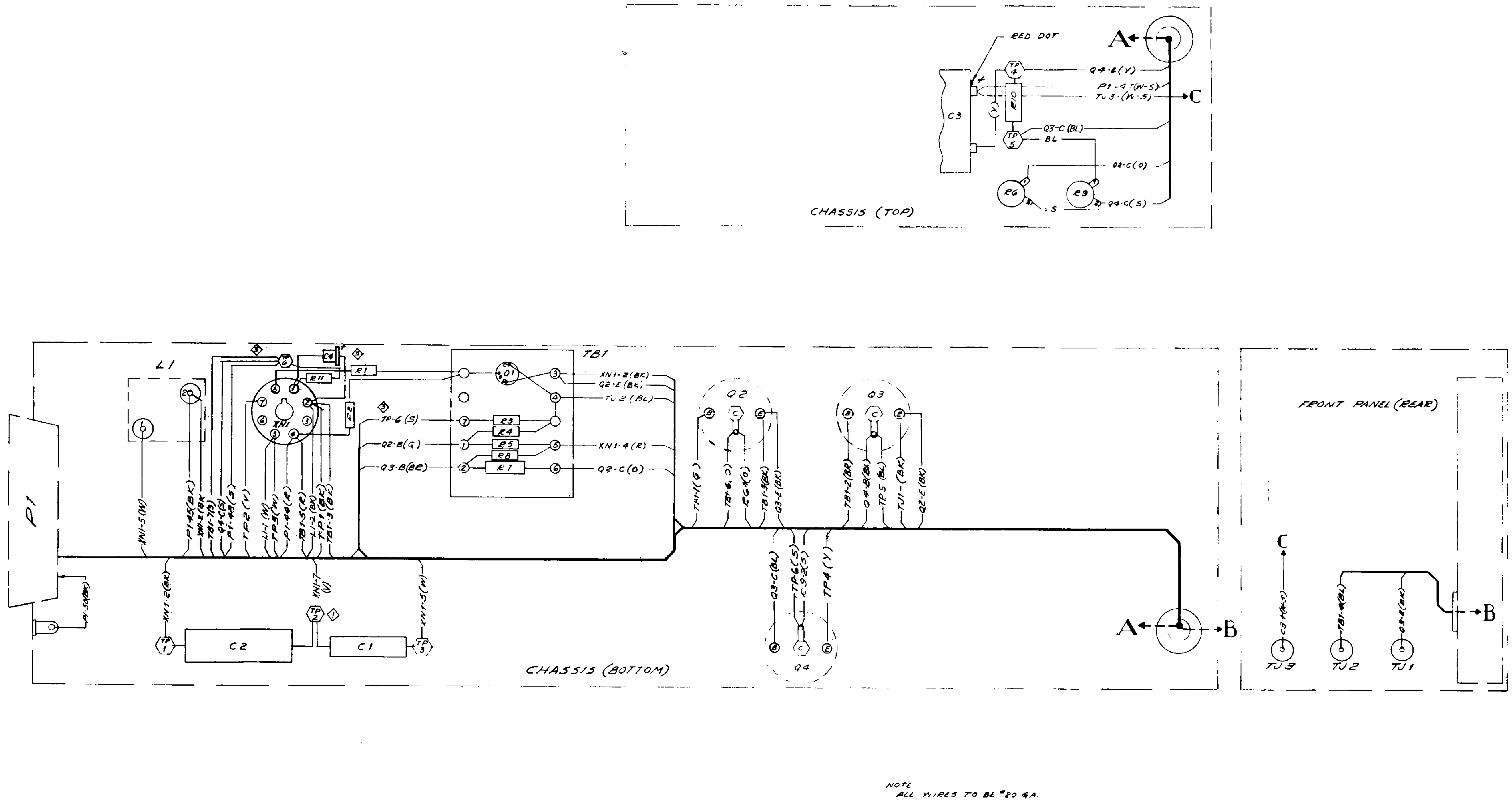
Figure 9-6. Wiring Diagram
20 Bit Shift Register
Dwg. #1576W7A



NOTE:

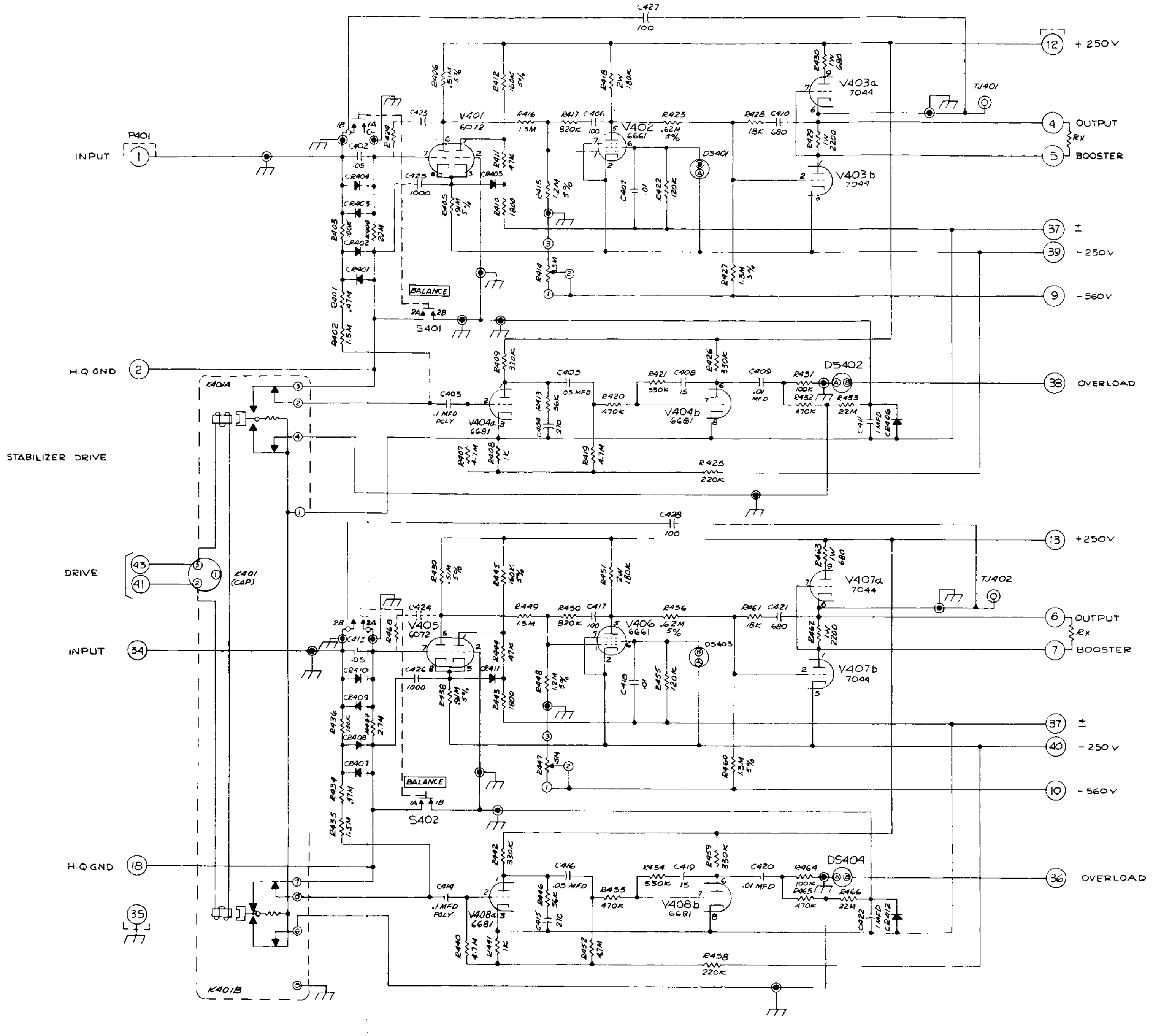
1. ALL RESISTORS ½W, ± 10% UNLESS OTHERWISE SPECIFIED.
2. * THIS UNIT MAY BE UTILIZED WITH MILGO POWER SUPPLY 165-4A WHICH SUPPLIES +12V & -20V.

Figure 9-7. Schematic
Chopper Drive Chassis
Dwg. #77S9A

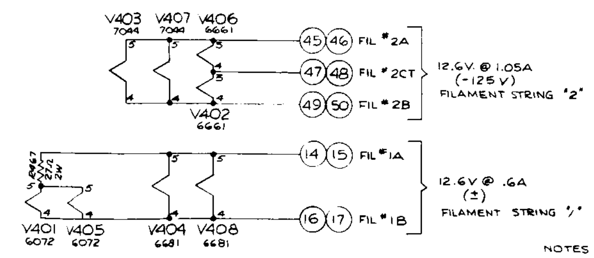


P1			
PIN	DEST.	FUNCTION	WIRE
40			
41			
42			
43			
44	XN1-4	+15V	R
45	L1-2	0V	BK
46			
47	C3(+)	CHOPPER DRIVE	(W-S)
48	TP-6	-25V	S
49			
50	GND LUG	CHASSIS GND	BK

Figure 9-8. Wiring Diagram
Chopper Drive Chassis
Dwg. #77W9A

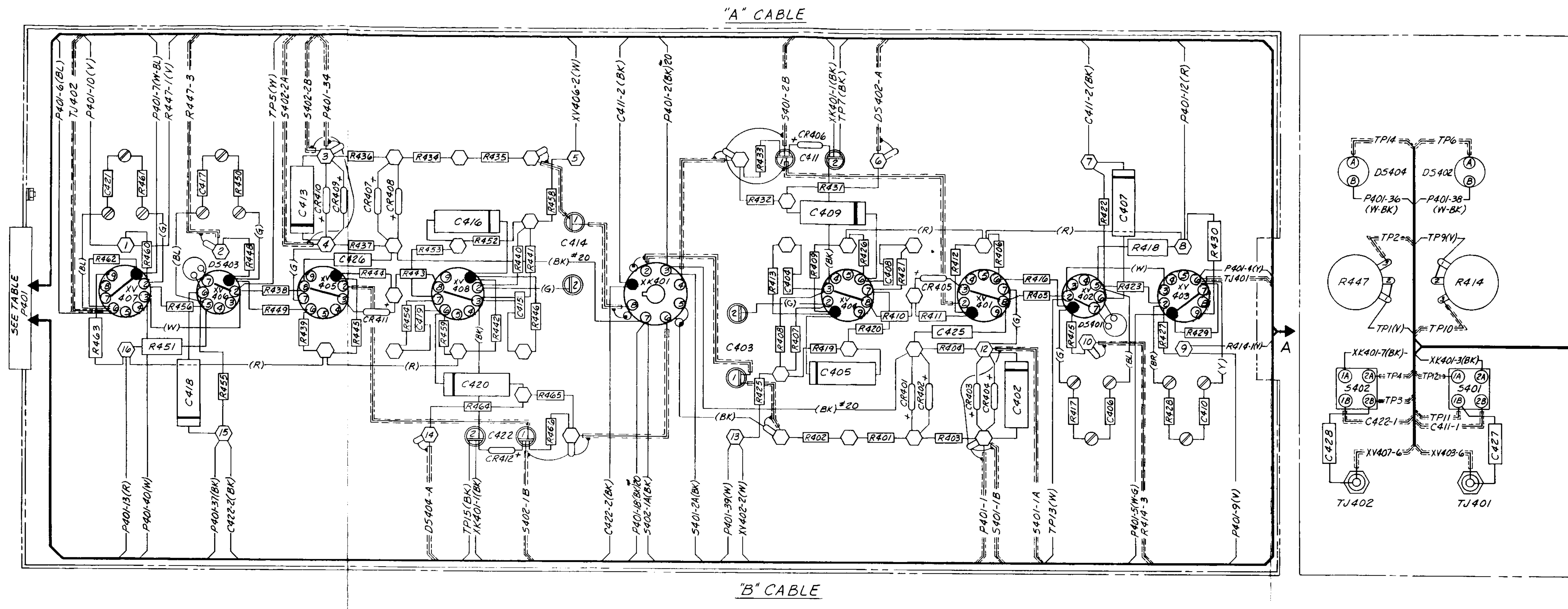


OUTPUT EXCURSION	OUTPUT LOAD	RX
± 140 V	5000 Ω	1000 Ω
± 140 V	6000 Ω	2200 Ω
± 140 V	7500 Ω	4700 Ω
± 140 V	10000 Ω OR MORE	NONE
± 100 V	2500 Ω	1800 Ω
± 100 V	3000 Ω	3300 Ω
± 100 V	4000 Ω OR MORE	NONE



NOTES
1. ALL RESISTORS TO BE ½W ± 10% UNLESS OTHERWISE SPECIFIED

Figure 9-9. Schematic
DC Amplifier Chassis
Dwg. #63S4C



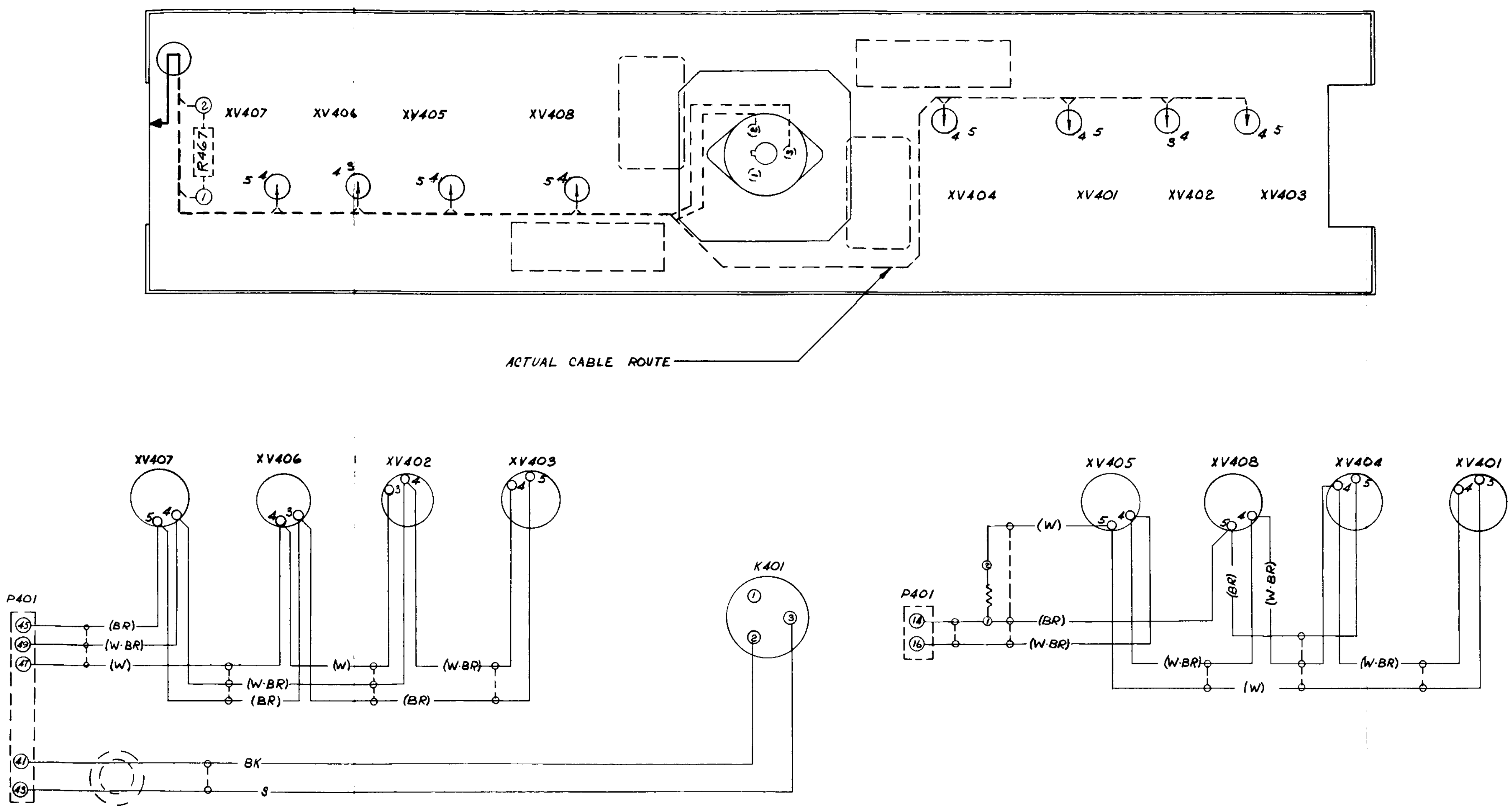
P401							
PIN	DESTINATION	FUNCTION	WIRE	PIN	DESTINATION	FUNCTION	WIRE
1	TP11	IMPUT, AMP A	COAX	26			
2	XK401-3	H.Q. GND	BK #20	27			
3				28			
4	XV403-6	OUTPUT, AMP A	Y	29			
5	XV403-1	BOOST, AMP A	W-G	30			
6	XV407-6	OUTPUT, AMP B	BL	31			
7	XV407-1	BOOST, AMP B	W-BL	32			
8				33			
9	TP9	-560V	V	34	TP3	INPUT, AMP B	COAX
10	TP1	-560V	V	35		CHASSIS GND	BK #20
11				36	DS404-B	OVERLOAD, AMP B	W-BK
12	TP8	+250V	R	37	TP15	± GND	W-BK
13	TP16	+250V	R	38	DS402-B	OVERLOAD, AMP A	BK
14	R467-1	FIL #1A	BR #22	39	TP13	-250V	W #22
15				40	XV407-3	-250V	W #22
16	XV401-4	FIL #1B	(W-BR) #22	41	XK401-2(CAP)	DRIVE	BK
17				42			
18	XK401-7	H.Q. GND	BK #20	43	XK401-3(CAP)	DRIVE	S
19				44			
20				45	XV407-5	FIL-2A	BK #22
21				46		FIL-2A	
22				47	XV406-4	FIL-2CT	W #22
23				48		FIL-2CT	
24				49	XV407-4	FIL-2B	(W-BR) #22
25				50		FIL-2B	

NOTE 3

NOTE 3

NOTES:
1. ALL WIRE TO BE #22 GA. UNLESS OTHERWISE NOTED.
2. ═══ INDICATES RG/174U COAX.
3. JUMPER PINS ON P401 AS SHOWN.
4. SEE SHEET NO. 2 FOR FILAMENT CABLE LAYOUT.
5. DO NOT TWIST DIODE LEADS.

Figure 9-10. Wiring Diagram DC Amplifier Chassis Dwg. #63W4C Sheet #1



NOTES:
1.) ALL WIRES TO BE #22 GAUGE
2.) o--o INDICATES TWISTED WIRES.
3.) FOR PLACEMENT OF CABLE, REFER TO ACTUAL CABLE ROUTE.

Figure 9-11. Wiring Diagram,
DC Amplifier Chassis
Dwg. #63W4C Sheet #2

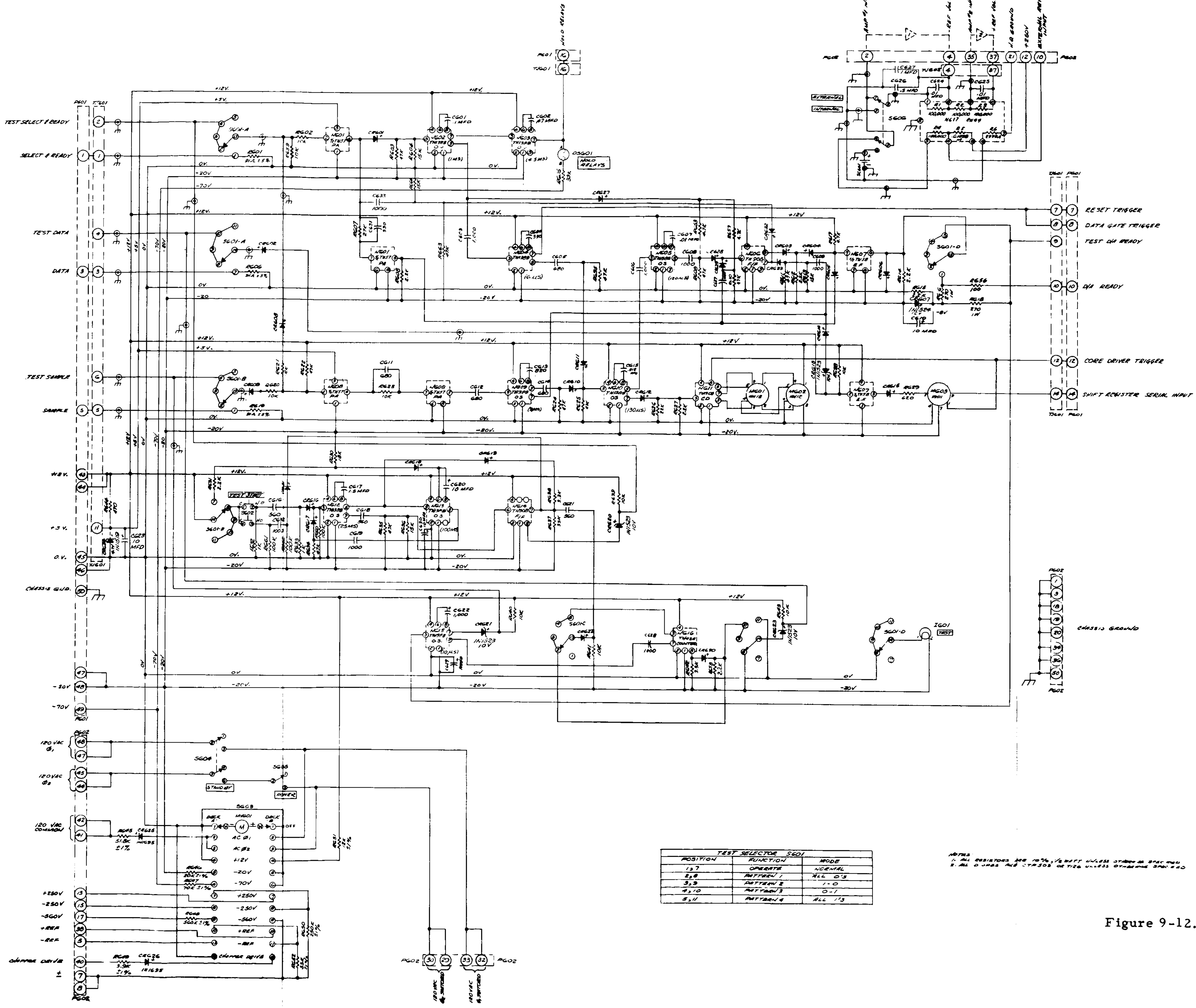
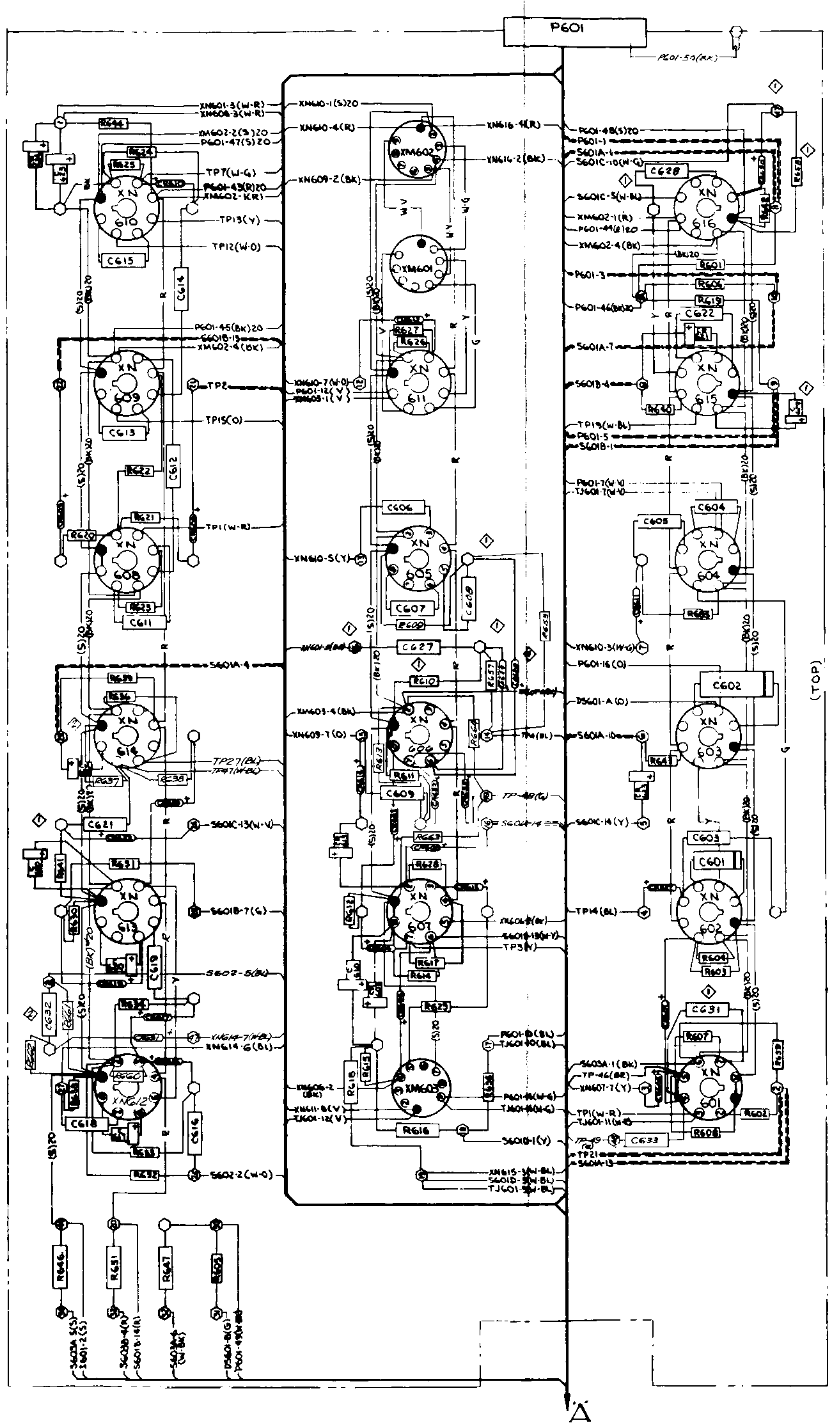


Figure 9-12. Schematic
Control Chassis
Dwg. #1576S6A



P601

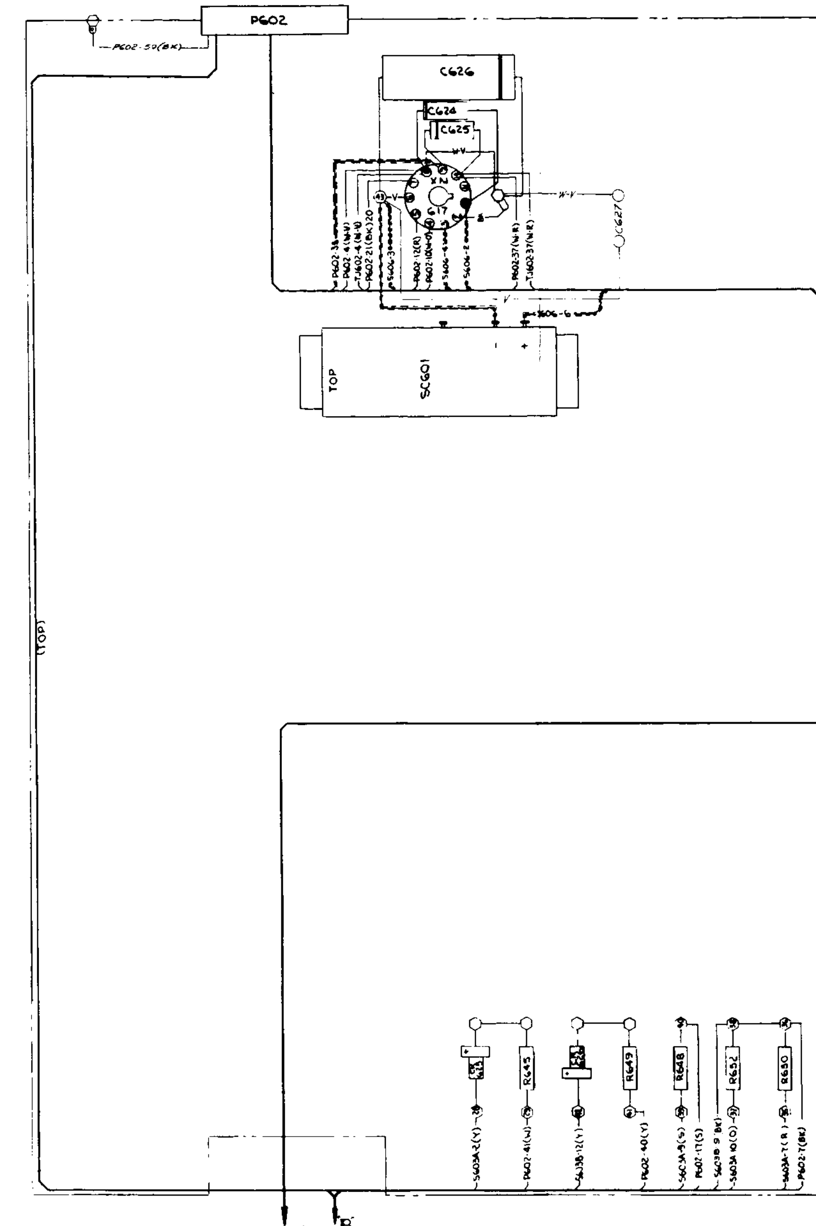
PIN	DESTINATION	FUNCTION	WIRE	PIN	DESTINATION	FUNCTION	WIRE
1	TP11	SELECT & READY	COAX	26			
2				27			
3	TP10	DATA	COAX	28			
4				29			
5	TP9	SAMPLE	COAX	30			
6				31			
7	XN604-7	RESET TRIGGER	W-V	32			
8		DATA GATE TRIGGER		33			
9				34			
10	TP17	D/A READY	BL	35			
11				36			
12	XN611-8	CORE DRIVE TRIGGER	V	37			
13				38			
14	XM603-9	SHIFT REGISTER SERIAL INPUT	W-G	39			
15				40			
16	XN603-/	HOLD RELAYS	O	41			
17				42			
18				43	XN610-4	+12V	(R) 20
19				44	XN616-4	+12V	(R) 20
20				45	XN609-2	0 V	(BK) 20
21				46	TP45	0 V	(BK) 20
22				47	XN610-1	-20V	(S) 20
23				48	XN616-1	-20V	(S) 20
24				49	TP30	-70 V	W-BK
25				50	GND. LUG	CHASSIS GND	BK

P602

PIN	DESTINATION	FUNCTION	WIRE	PIN	DESTINATION	FUNCTION	WIRE
1				26			
2	S606-1	AMP #1 INPUT	COAX	27			
3				28			
4	XN617-8	-REF VOLT	W-V	29	S605-3	Φ2 SWITCHED	(W-BR)20
5	S603A-11	-REF	W-V	30	S605-3	Φ2 SWITCHED	(W-BR)20
6				31			
7	TP36	⏚	BK	32	S604-3	Φ1 SWITCHED	(BR)20
8		⏚		33	S604-3	Φ1 SWITCHED	(BR)20
9				34			
10	XN617-4	EXT. REF INPUT	W-O	35	XN617-9	AMP #2 INPUT	COAX
11				36			
12	XN617-5	+250V	R	37	XN617-10	+REF	W-R
13	S603B-7	+260V	R	38	S603B-10	+REF	W-R
14				39			
15	S603A-8	-250V	W-S	40	TP41	CHOPPER DRIVE	Y
16				41	TP29	120VAC COMMON	W
17	TP40	-560V	S	42		120 VAC COMMON	
18				43			
19				44	S604-5	Φ2 120 VAC	(W-BR)20
20				45	S604-5	Φ2 120 VAC	(W-BR)20
21	XN617-7	H.Q. GND	(BK)20	46			
22				47	S604-2	Φ1 120 VAC	(BR) 20
23				48	S604-2	Φ1 120 VAC	(BR) 20
24				49			
25				50	GND. LUG	CHASSIS GND	BK

JUMPER PINS 7 & 8; 41 & 42; & 1,3,18,19,20,34,36,50.

INDICATES JUMPERED TERMINALS

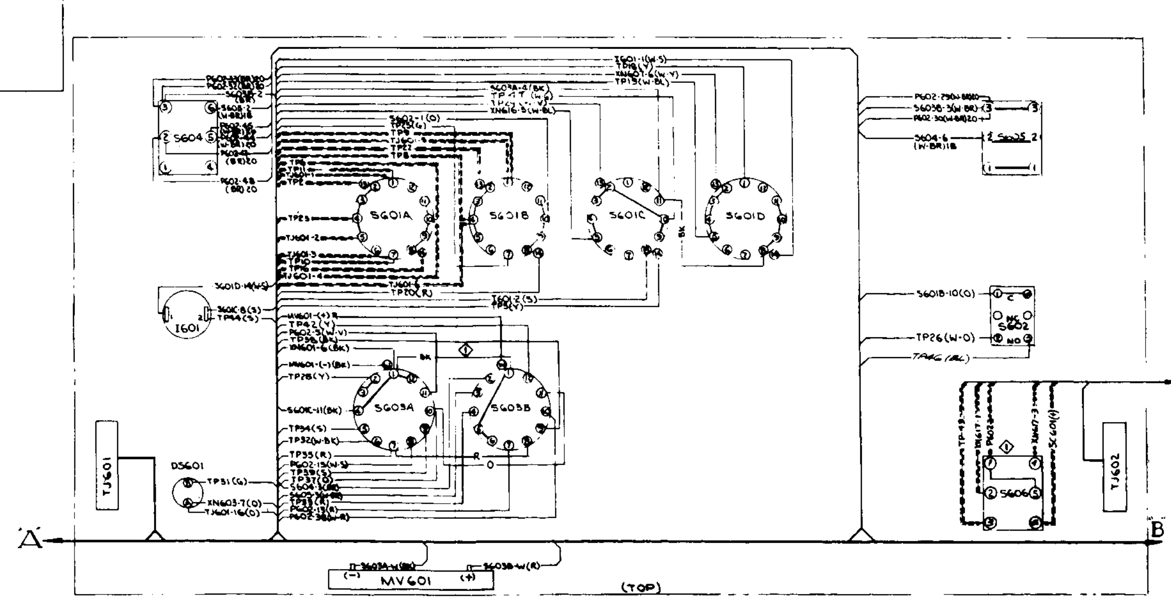


TJ602

PIN	DESTINATION	FUNCTION	WIRE
4	XN617-8	-REF VOLT.	W-V
37	XN617-10	+REF. VOLT.	W-R

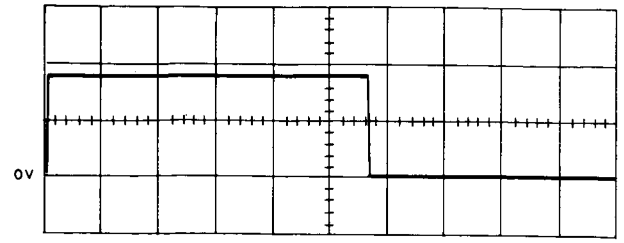
TJ601

PIN	DESTINATION	FUNCTION	WIRE
1	S601A-1	SELECT & READY	COAX
2	S601A-5	TEST S&R	COAX
3	S601A-7	DATA	COAX
4	S601A-10	TEST DATA	COAX
5	S601B-1	SAMPLE	COAX
6	S601B-4	TEST SAMPLE	COAX
7	XN604-7	RESET TRIGGER	W-V
8		DATA GATE TRIGGER	
9	TP19	TEST D/A READY	W-BL
10	TP17	D/A READY	BL
11	XN601-3	+5V	W-R
12	XM603-1	CORE DRIVE TRIGGER	V
14	XM603-9	SHIFT REGISTER SERIAL INPUT	W-G
16	DS601-A	HOLD RELAYS	O

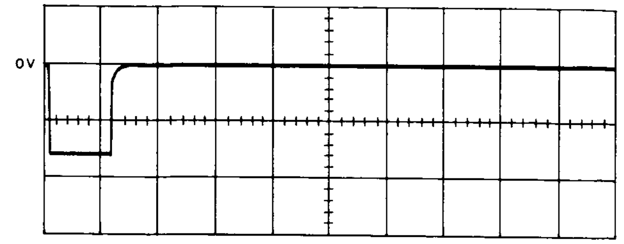


NOTES:
1. ALL WIRE TO BE #22 GA. UNLESS OTHERWISE SPECIFIED.
2. GROUND ONE END ONLY OF ALL COAX SHIELDS.
3. COAX TO BE TYPE RG-174/U.
4. ▬▬ INDICATES COAX
5. ① INDICATES TIE POINT.

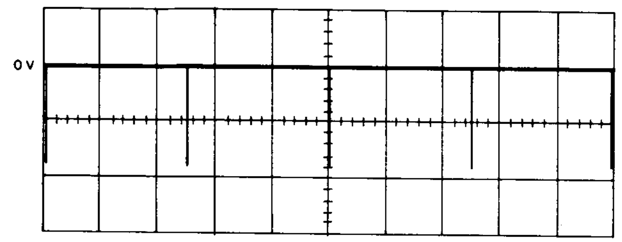
Figure 9-13. Wiring Diagram
Control Chassis
Dwg. #1576W6A



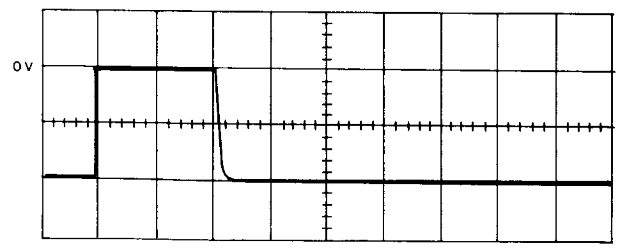
a. Select & Ready (TJ601-1)*
5v and 2MS/division
Sync from TJ601-1 (Ext. plus)



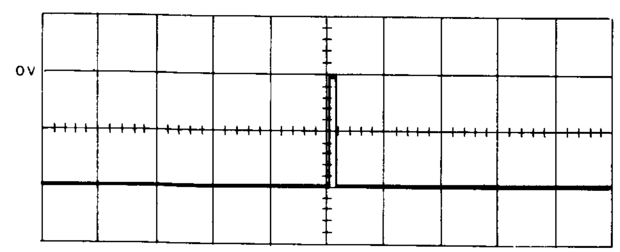
b. D/A Ready (TJ601-10)
5v and 10 micro S/division
Sync from TJ601-1 (Ext. plus)



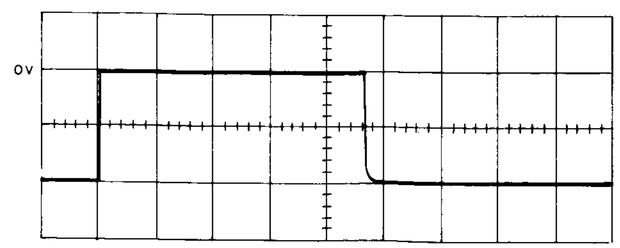
c. D/A Ready (TJ601-10)
5v and 100 micro S/division
Sync from TJ601-1 (Ext. plus)



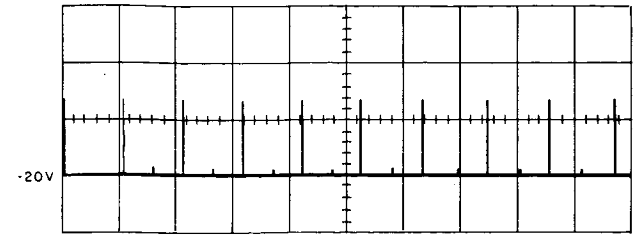
d. Core Driver Trigger (TJ601-12)
10v and 10 micro S/division
Sync from TJ601-5 (Ext. plus)



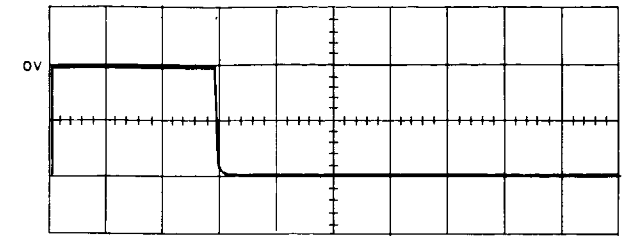
e. Reset Trigger (TJ601-7)
10v and 200 micro S/division
Sync from TJ601-1 (Ext. minus)



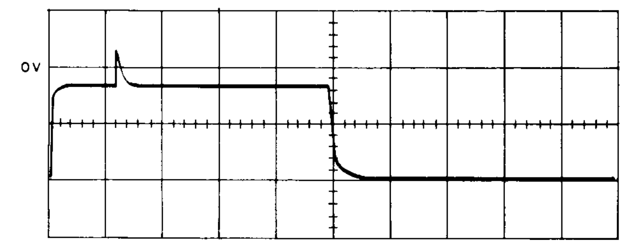
f. D/A Hold (TJ601-16)
10v and 1 MS/division
Sync from TJ601-1 (Ext. minus)



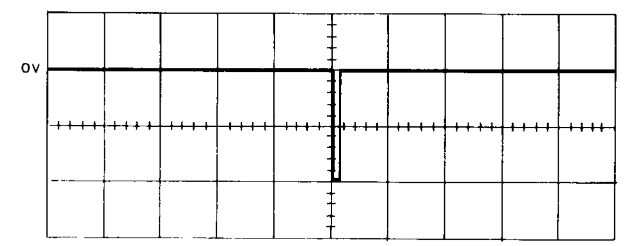
g. Data to Shift Register (TJ601-14)**
5v and 500 micro S/division
Sync from TJ601-12 (Ext. plus)



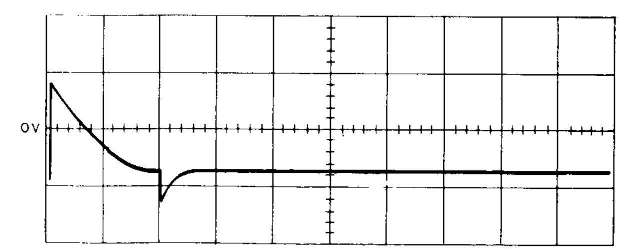
h. Reset Trigger (TJ601-7)
10v and 2 micro S/division
Sync from internal



i. Input to N701 (M701-4)***
10v and 10 micro S/division
Sync from TJ701-32 (Ext. plus)



j. N701 Output (TJ701-1)***
10v and 200 micro S/division
Sync from TJ601-1 (Ext. minus)



k. Reset (TJ701-33)
10v and 5 micro S/division
Sync from internal

*the time length of this pulse will vary with the use of this D/A with other equipment and will be much longer in some applications
** "1-0" data pattern
*** all "1" data pattern

Figure 9-14. Waveforms

CHAPTER X

APPENDIX

POWER SUPPLY
MEC MODEL 165-4A

1. GENERAL DESCRIPTION

A Milgo type 165-4A Power Supply has three outputs: the first, a +12 volts (+1 volt, -3 volts) at one ampere output; the second, a -20 volts (+2 volts, -6 volts) at two amperes output; and the third, a -50 volts ±5 volts at one ampere output. The -50 volt Supply is stacked on the bottom of the -20 volt Supply, thereby giving an output of -70 volts. The a-c input of this Supply can vary from 100 vac to 130 vac and from 45 to 60 cycles. The unit is mounted in a standard Milgo slide-type rack and has a front panel 8 3/4 inches high by 8 7/8 inches wide. Its weight is 35 pounds.

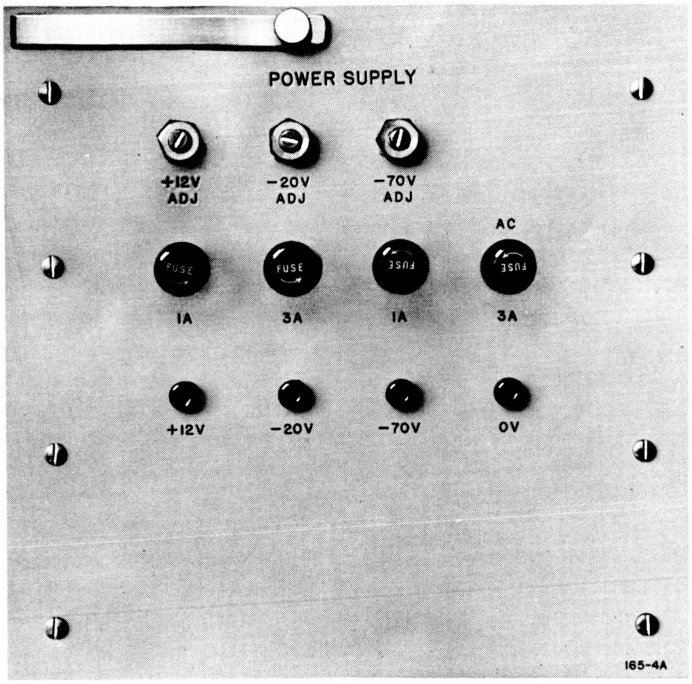
2. THEORY OF OPERATION

2-1. 12 Volt Supply

2-1.1. A portion of the output of transformer T401 is rectified by a bridge rectifier CR401 and filtered by resistor R401 and capacitors C401 and C402. The voltage across capacitors C401 and C402 is normally 20 volts (approximately). Transistor Q401 and resistors R402 and R403 act as a variable resistance element in series with the output load, which can be varied to maintain a constant output voltage across a variable load. As the load current increases, the effective resistance of Q401 is decreased so that the IR drop across R402, R403, and Q401 will remain constant producing a constant output voltage. If the input a-c line voltage should increase, the d-c voltage across filtered capacitors C401 and C402 would increase and the effective resistance of Q401 must increase again so that the output voltage will remain constant.

2-1.2. The effective resistance of Q401 is controlled by the control section, consisting of transistors Q402, Q403, Q404, and their associated circuitry. Q404 determines whether the output voltage is too high or too low and is followed by power amplifiers Q403 and Q402, which amplify the control signal to the necessary power level for driver Q401. The base voltage of Q404 is referenced from the voltage of a 4.7 volt zener diode CR402. The emitter voltage of Q404 is determined by the resistor divider network of R413, R414, and R415. The voltage from the wiper of potentiometer R414 is applied to the emitter of Q404.

2-1.3. As the output voltage increases, the magnitude of the voltage from the wiper of R414 will also increase proportionally. Since the voltage across CR402 remains constant as the output voltage increases, the emitter voltage tends to go positive with respect to the base voltage, driving Q404 toward cutoff. As Q404 goes toward cutoff, there is less collector current through R410, so there is less base current in Q403. The emitter current of Q403 decreases, reducing the current through R407 and base current of Q402. With less base current in Q402, the emitter current decreases, reducing the base current of Q401. With less base current, the effective resistance of Q401 will increase. Therefore, the output voltage decreases until Q404 senses the correct relationship between the output voltage and the zener voltage of CR402.



MEC MODEL 165-4A Power Supply

2-1.4. If the output voltage decreases below the desired value, the portion of the output voltage applied to the emitter of Q404 also decreases, tending to make the emitter more negative with respect to the base. This increases the collector current of Q404, which increases the base current of Q403, thus increasing the emitter current of Q403 and the base current of Q402. This in turn increases the emitter current of Q402 and the base current of Q401, which reduces the effective resistance of Q401, causing the output voltage to return to its regulated value. Q404 actually is matching the zener voltage to the emitter voltage.

2-1.5. Since a portion of the output voltage applied to the emitter of Q404 can be varied by potentiometer R414, and the emitter voltage of Q404 is to remain constant, the output voltage must be changed as the resistor R414 is changed. In this manner, the regulated output voltage can be adjusted over a range of +9 volts to +15 volts. Capacitor C403 has been added to prevent hunting. Resistors R402 and R403 are included to limit the peak current to transistor Q401 to a safe value if the output terminal is short circuited, and to provide reverse bias for Q401 and Q402. Resistor R404 provides a path for the leakage current of Q402 so that this current does not affect the base current in Q401, allowing Q401 to be more nearly cut off during a light load.

2-2. -20 Volt Supply

2-2.1. A second portion of the output of transformer T401 is rectified by bridge rectifier CR421 and filtered by parallel resistors R421A and R421B, and capacitors C421, C422, and C423. The d-c voltage across capacitors C421, C422, and C423 is approximately 30 volts. Transistors Q421 and Q422 with their associated resistors R423, R424, and R422, act as a variable resistance element in series with the output load, which can be varied to maintain a constant output voltage across a variable load. As the load current increases, the effective resistance of Q421 and Q422 is decreased so that the IR drop across R422, R423, R424, Q421, and Q422 will remain constant, producing a constant output voltage.

2-2.2. If the input a-c line voltage should increase, the d-c voltage across filter capacitors C421, C422, and C423 would increase, and the effective resistance of Q421 and Q422 must increase again to keep the output voltage constant. The effective resistance of Q421 and Q422 is controlled by the control section, consisting of transistors Q423, Q424, and Q425 and their associated circuitry. Transistor Q425 determines whether the output voltage is too high or too low and is followed by power amplifiers Q424 and Q423, which amplify the control signal to the necessary power level for driving Q421 and Q422. The base voltage of Q425 is referenced from the voltage of a 4.7 volt zener diode CR422. The emitter voltage of Q425 is determined by a resistor divider network R434, R435, and R436. The voltage from the wiper of potentiometer R435 is applied to the emitter of Q425.

2-2.3. As the output voltage increases, the magnitude of the voltage from the wiper of R435 will increase proportionally. Since the voltage across CR422 remains constant as the output voltage increases, the emitter voltage tends to become positive with respect to the base voltage, driving Q425, which is an NPN transistor, toward cutoff. As Q425 goes toward cutoff, there is less collector current through R431, and consequently, there is less base current in Q424. With less base current in Q424, the emitter current of Q424 decreases. With less emitter current in Q424, the current through R428 and the base current of Q423 also decrease. This reduces the emitter current in Q423 and reduces the base current in Q421 and Q422. Less base current in Q421 and Q422 increases their effective resistance, which increases the IR drop across them. Therefore, the output voltage decreases until Q425 senses the correct relationship between the output voltage and the zener voltage of CR422.

2-2.4. Conversely, if the output voltage decreases below the desired value, the portion of the output voltage applied to the emitter of Q425 also decreases, tending to make the emitter more negative with respect to the base. This increases the collector current of Q425, increasing the base current of Q424, which in turn increases the emitter current of Q424 and the base current of Q423. This, in turn, increases the emitter current of Q423 and the base current of Q421 and Q422, reducing the effective resistance of Q421 and Q422, and causing the output voltage to return to its regulated value. Transistor Q425 is actually matching the zener voltage to the emitter voltage.

2-2.5. Since a portion of the output voltage applied to the emitter of Q425 can be varied by potentiometer R435, and the emitter voltage of Q425 is to remain constant, the output voltage will have to be changed as the resistor R435 is changed. In this manner, the regulated voltage of this supply can be adjusted from -14 volts to -22 volts. Capacitors C425 and C424 provide feedback for stabilization purposes.

2-2.6. Resistors R423 and R424 serve two functions. First, they force the collector current of Q421 and Q422 to balance. Since the bases are tied in common, if one transistor conducts more than the other, the higher IR drop in their associated resistor would tend to reverse bias the transistor with the most current and, in this manner, force the currents to balance. Second, if the output supply is shorted, resistors R423 and R424 limit the peak current through Q421 and Q422 to a safe value while fuse F402 is blowing. Resistor R425 provides a path for the leakage current of Q423 so that this leakage current does not affect the base current in Q421 and Q422. This allows Q421 and Q422 to be more nearly cut off during a light load.

2-3 -50 Volt Supply

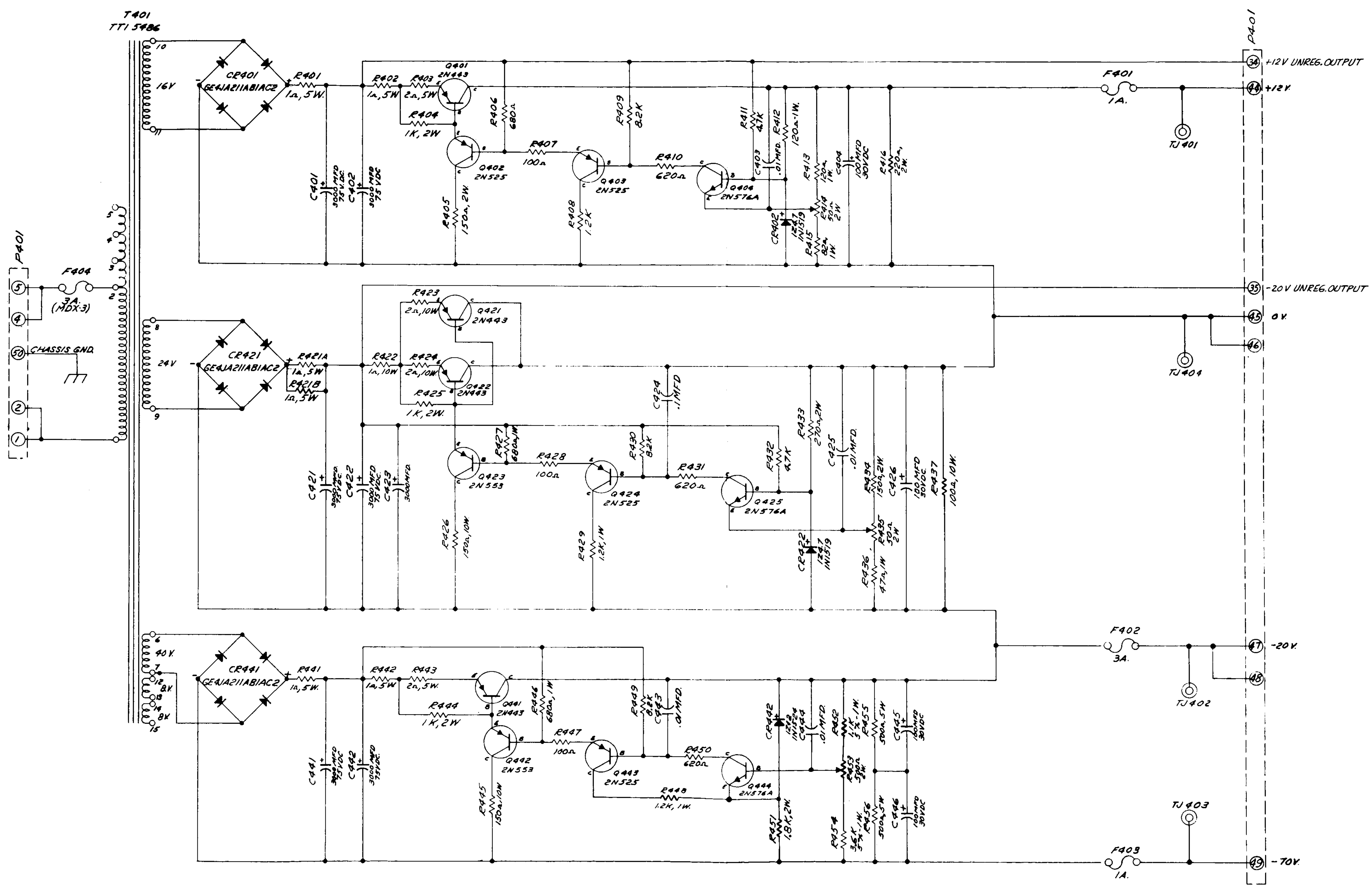
2-3.1. A third portion of the output of transformer T401 is rectified by a bridge rectifier CR441 and filtered by resistor R441 and capacitors C441 and C442. The voltage across capacitor C441 and C442 is normally 60 volts (approximately). Transistor Q441, and resistors R442 and R443, act as a variable resistance element in series with the output load, which can be varied to maintain a constant output voltage across a variable load. As the load current increases, the effective resistance of Q441 is decreased so that the IR drop across R442, R443, and Q441 will remain constant, producing a constant output voltage. If the input a-c line voltage increases, the d-c voltage across filtered capacitors C441 and C442 will increase and the effective resistance of Q441 must increase again so that the output voltage will remain constant.

2-3.2. The effective resistance of Q441 is determined by the control section, consisting of transistors Q442, Q443, and Q444 and their associated circuitry. Q444 determines whether the output voltage is too high or too low and is followed by power amplifiers Q443 and Q442. These amplify the control signal to the necessary power level for driver Q441. The emitter voltage of Q444 is referenced from the voltage of a 12 volt zener diode CR442. The base voltage of Q444 is determined by the resistor divider network of R452, R453, and R454. The voltage from the wiper of potentiometer R453 is applied to the base of Q444. The zener is referenced from the positive side of this supply to reduce the emitter-to-collector voltage of Q443 and Q444 to less than 25 volts.

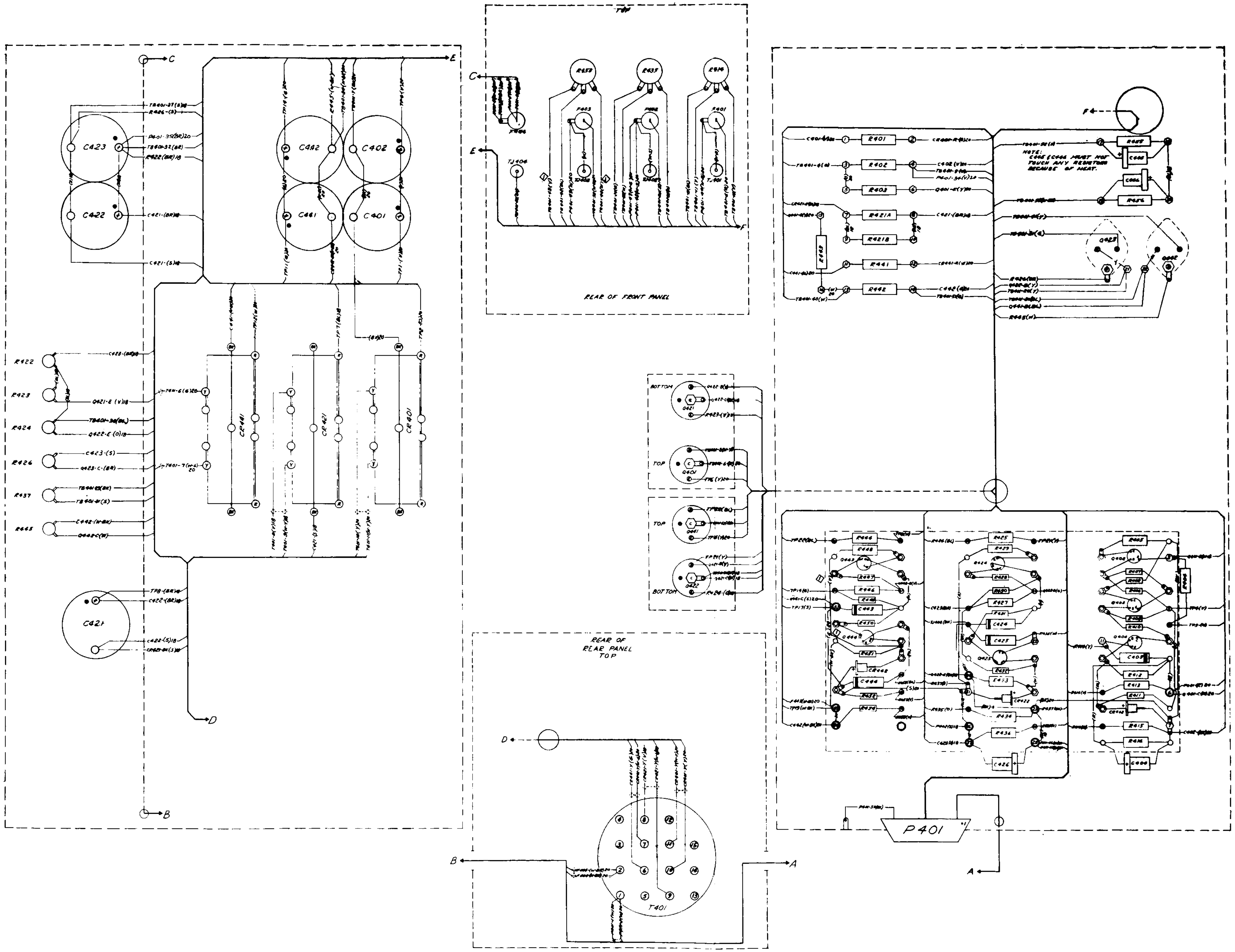
2-3.3. As the output voltage increases, the magnitude of the voltage from the wiper of R453 will also increase proportionally. Since the output across CR442 remains constant as the output volts increase, the base voltage tends to become negative with respect to the emitter voltage, driving Q444 toward cutoff. As Q444 goes toward cutoff, there is less collector current through R450 and less base current in Q443. The emitter current decreases, reducing the current through R447 and the base current of Q442. With less base current in Q442, the emitter current decreases, reducing the base current of Q441. With less base current, the effective resistance of Q441 increases. Therefore, the output voltage decreases until Q444 senses the correct relationship between the output voltage and the zener voltage of CR442.

2-3.4. If the output voltage decreases below the desired value, the portion of the output voltage applied to the base of Q444 also decreases, tending to make the base more positive with respect to the emitter. This increases the collector current of Q444, increasing the base current of Q443, and increasing the emitter current of Q443 and the base current of Q442. This in turn increases the emitter current of Q442 and the base current of Q441, reducing the effective resistance of Q441, and causing the output voltage to increase and to return to its regulated value. Q444 is actually matching the zener voltage to the base voltage.

2-3.5. Since a portion of the output voltage applied to the base of Q444 can be varied by potentiometer R453, and the base voltage of Q444 is to remain constant, the output voltage will have to be changed as the resistor R453 is changed. In this manner, the regulated output voltage can be adjusted over a range of -45 volts to -55 volts. Capacitors C443 and C444 have been added to prevent hunting. Resistors R442 and R443 are included to limit the peak current ot transistor Q441 to a safe value if the output terminal is short circuited, and to provide reverse bias for Q441 and Q442. Resistor R444 provides a path for the leakage current of Q442 so that this current does not affect the base current in Q441. This allows Q441 to be more nearly cut off during a light load. This -50 volt Power Supply is stacked on the bottom of the -20 volt Supply, giving a combined output of -70 volts.



Schematic
165-4A Power Supply
Dwg. # 165S4A



NOTES:
1. ALL WIRE 22GA. UNLESS SPECIFIED
2. ALL AC WIRES TO BE TWISTED IN PAIRS.

P401							
PIN	DEST.	FUNCTION	WIRE	PIN	DEST	FUNCTION	WIRE
1	T401-1	AC INPUT	(W) 20	41			
2	T401-1	AC INPUT	(W) 20	42			
3				43			
4	F404	AC INPUT	(BR) 20	44	F401	+12 V	(W-R) 20
5	F404	AC INPUT	(BR) 20	45	TB401-25	0 V	(BK) 20
6				46	TB401-25	0 V	(BK) 20
7				47	F402	-20 V	(W-S) 20
8				48	F402	-20 V	(W-S) 20
34	TP4	+12V UNREG.	(V) 20	49	F403	-20 V	(W) 20
35	C423	-20V UNREG.	(BR) 20	50	CHASSIS	CHASSIS GND	(BK)

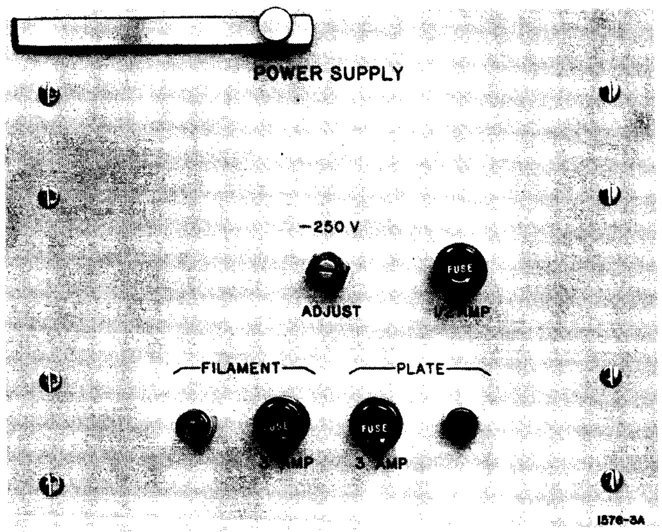
Wiring Diagram
165-4A Power Supply
Dwg. #165W4A

POWER SUPPLY
MEC MODEL 1576-3A

1. GENERAL DESCRIPTION

1-1. The -250volt, 250ma, -560volt, 15ma Power Supply has 3 outputs; -250 volts, -560 volts, and 12.6vac, center tapped. The 12.6vac Supply is capable of furnishing 7 amperes to external filament circuits. The primary windings of transformers T301 and T302 are tapped to compensate for high or low line voltages. If the line voltage is predominantly high, (125 volts or greater),the taps should be moved from terminal 3 to terminal 4. If the line voltage is low (105 volts or less),the taps should be moved from terminal 3 to terminal 2. An amber indicator DS302, labeled FILAMENT and a red indicator DS301, labeled PLATE indicate that transformers T302 and T301 have been energized. Input and output fuses, and a -250volt adjust potentiometer R327 are provided. The output of transformer T301 is full wave rectified by silicon diodes CR301 through CR308, filtered by inductor L301, and capacitors C301, C305, and C306, and is applied to the plates of series regulator tubes V301-V303, which regulate the output to -250 volts. Resistors R301 and R302 insure equal division of voltage between capacitors C305 and C306.

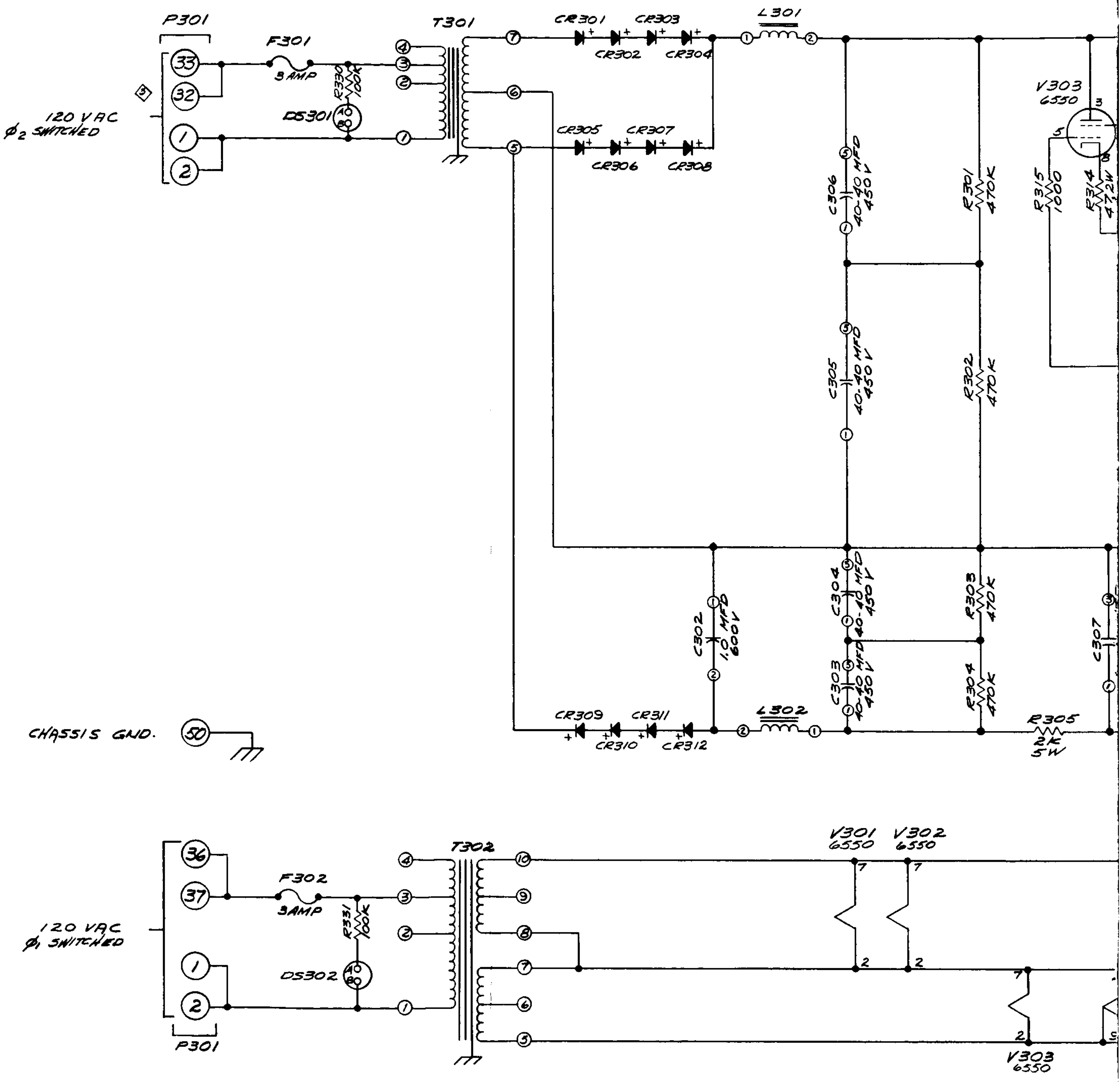
1-2. The output from terminal 5 to T301 is applied to a negative half wave rectifier consisting of silicon diodes CR309 thru CR312, then on to a filter consisting of inductor L302, capacitors C302 thru C304 and C307, and resistor R305, and then applied to VR tubes V306 and V307, which are placed across the -250volt, -560 volt outputs. Resistors R303 and R304 insure an equal division of voltage between capacitors C303 and C304, and resistor R332 insures proper firing of the VR tubes when power is turned on.

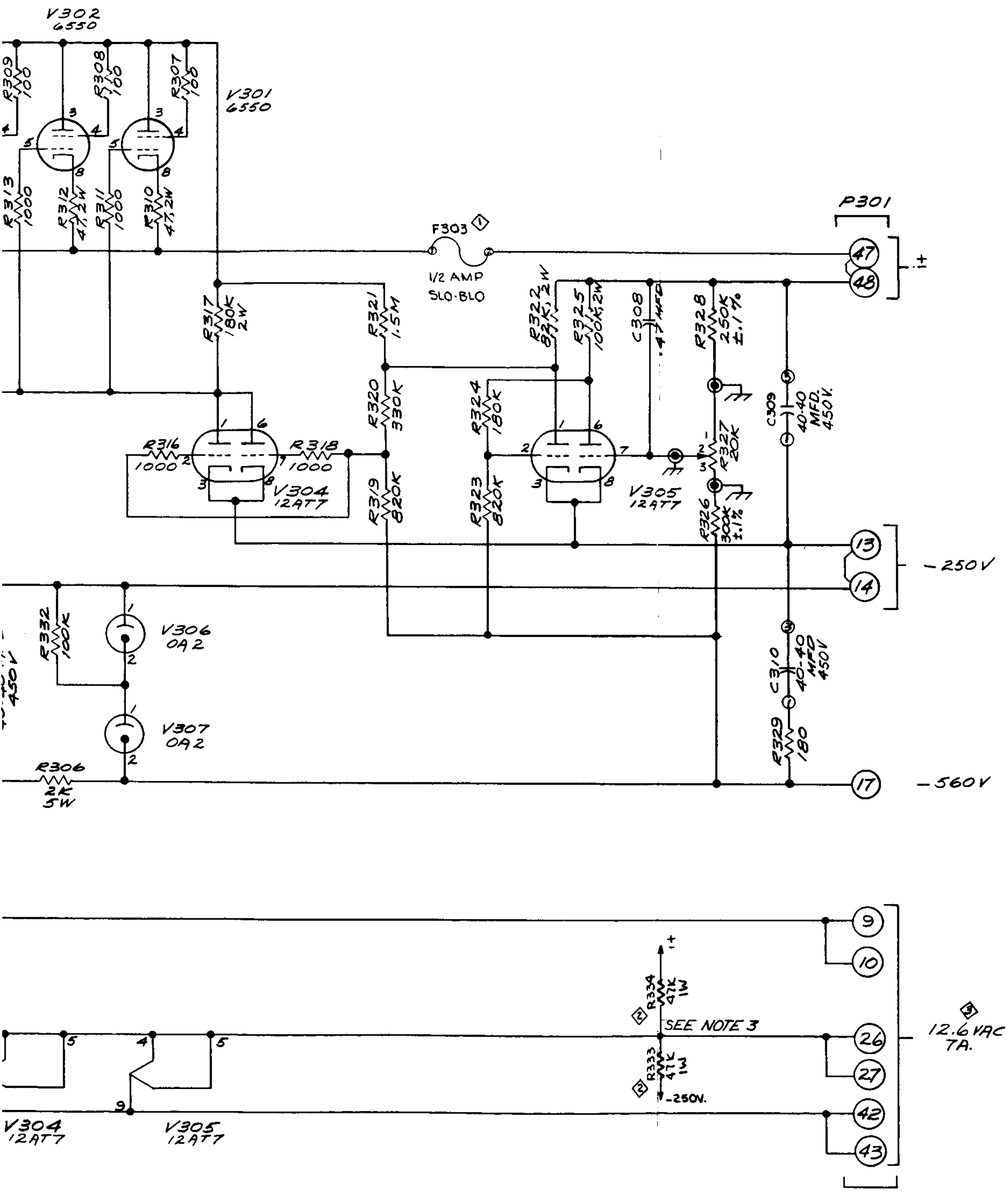


MEC Model 1576-3A Power Supply

2. DETAILED DESCRIPTION

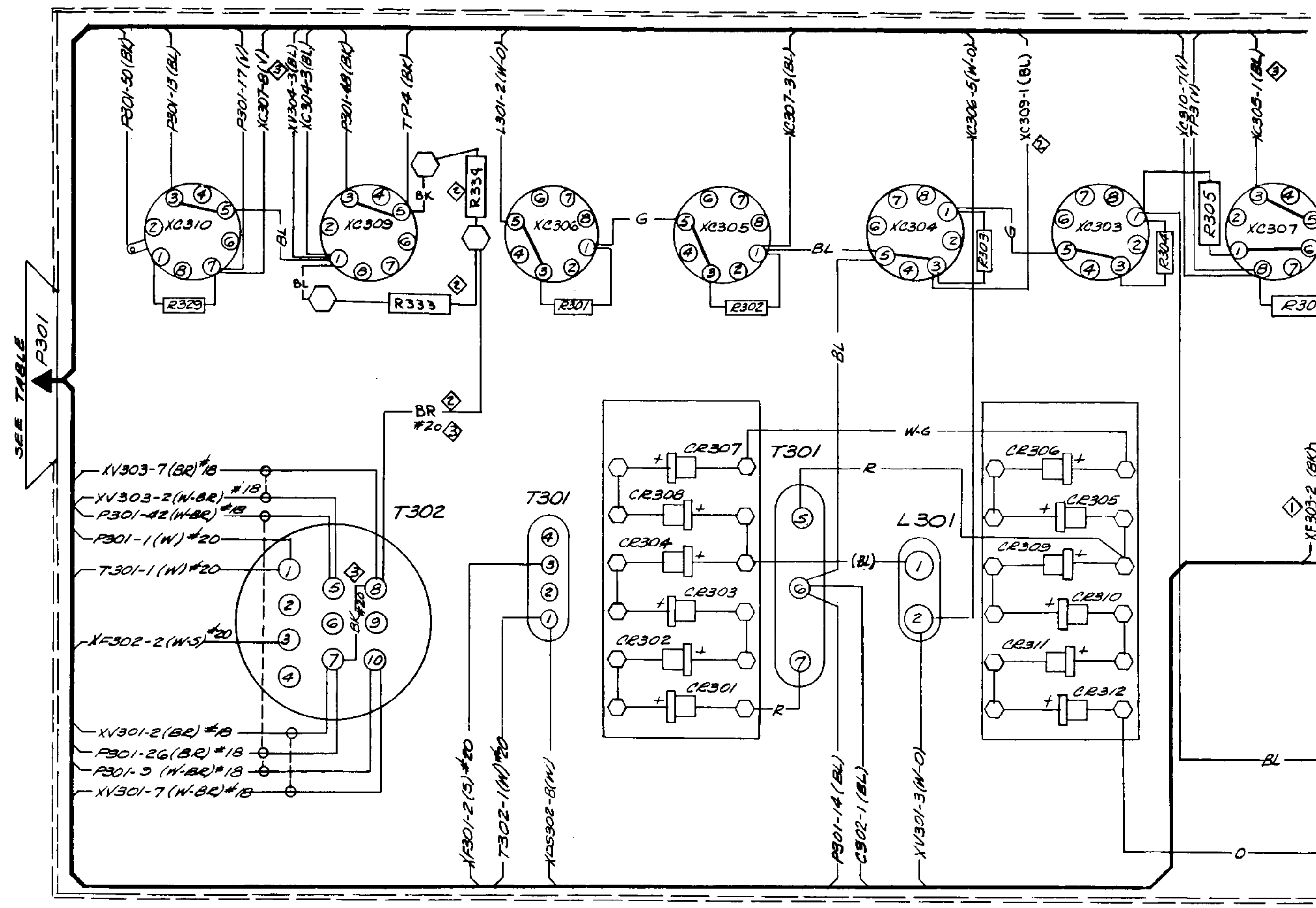
The -310 volts generated by VR tubes V306 and V307 of the -250 volt Power Supply is applied to a resistor divider consisting of resistors R326, R327, and R328. This resistor string compares the VR tube output to the -250 volt output. The error voltage appearing on the wiper of potentiometer R327 is amplified by tube V305 and directly coupled to amplifier tube V304 which in turn drives the grids of the three series regulator tubes V301, V302, and V303. If the -250 volt output increases, pin 7 of V305 goes more positive with respect to pin 8 of V305. Pin 6 plate of V405 becomes more negative, and the pin 1 plate of V405 becomes more positive, causing the plates, pins 1 and 6 of V404 to become more negative. This causes the grids of the three regulator tubes to become more negative, and since these regulators act essentially as cathode followers, their cathodes also become more negative, thereby reducing the output voltage. Similarly, if the output voltage were to go negative, the grids of the three regulator tubes would go positive tending to cause the output voltage to remain constant. Should a change occur in the -560 volt Power Supply voltage, the -250 volt Supply will change proportionally due to the resistor divider R326, R327, and R328, thus keeping the supply voltages to the DC Amplifiers balanced.


P301
120 VAC
φ2 SWITCHED
F301
3AMP
R330
100K
DS301
T301
CR301
CR302
CR303
CR304
CR305
CR306
CR307
CR308
L301
C306
40-40 MFD
450 V
C305
R301
470K
R302
470K
V303
6550
R315
1000
R314
C304
C303
C302
1.0 MFD
600 V
R303
470K
R304
470K
C307
CR309
CR310
CR311
CR312
L302
R305
2K
5W
CHASSIS GND.
T302
F302
3AMP
R331
100K
DS302
120 VAC
φ1 SWITCHED
V301
6550
V302
6550
V303
6550

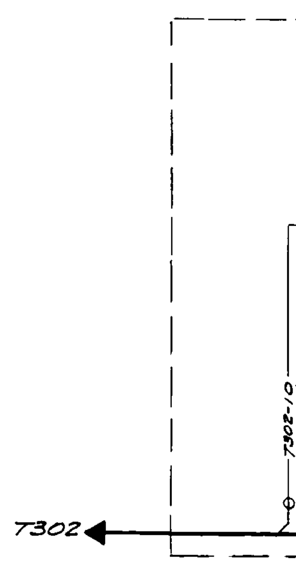


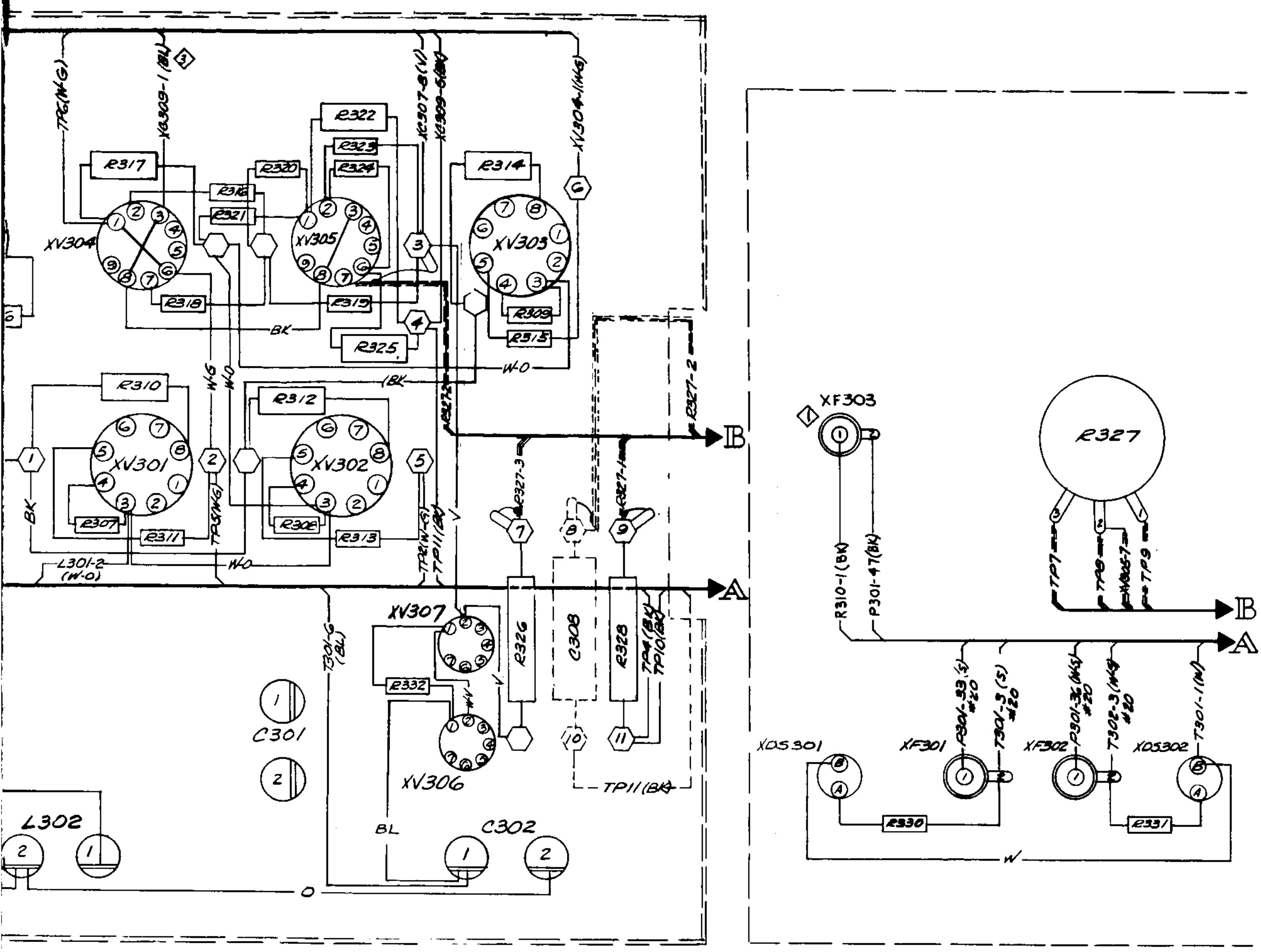
NOTES:
1. ALL RESISTORS TO BE 1/2 W, ±10% UNLESS OTHERWISE SPECIFIED.
2. CR301-CR312 ARE IN1695.
3. FOR 4008A1C & 4008A2C DELETE R333 & R334.

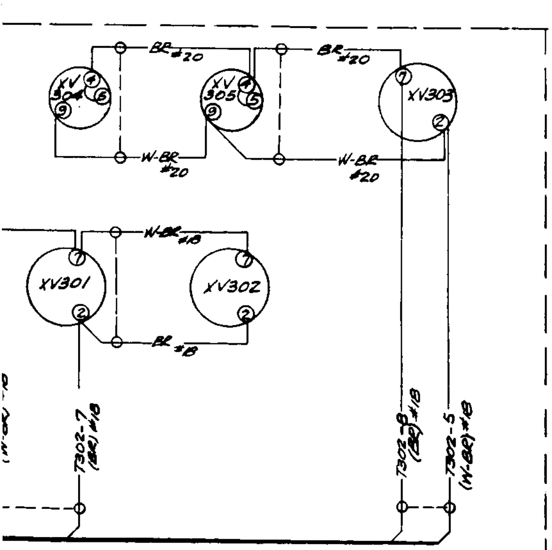
Schematic
1576-3A Power Supply
Dwg. # 1576S3A



P301					
TERM	DESTINATION	FUNCTION	TERM	DESTINATION	FUNCTION
1	T302-1 (W) #20	120 VAC	26	T302-7 (BR) #18	FIL. CT
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33	XF301-1 (S) #20	120 VAC
9	T302-10 (W-BR) #18	12.6 VAC	34		
10			35		
11			36	XF302-1 (W-S) #20	120 VAC
12			37		
13	XC310-3 (BL)	-250	38		
14	T301-6 (BL)		39		
15			40		
16			41		
17	XC310-7 (V)	-560	42	T302-5 (W-BR) #18	12.6 VAC
18			43		
19			44		
20			45		
21			46		
22			47	XF303-1 (BK)	±GND
23			48	XC309-3 (BK)	
24			49		
25			50	CHASSIS GND XC310	







FILAMENT WIRING

NOTES:
1. ALL WIRE TO BE #22 GA. UNLESS OTHERWISE SPECIFIED
2. ▬▬ INDICATES RG174/U COAX
3. ① INDICATES TIE POINT
4. O—O INDICATES TWISTED PAIRS

Wiring Diagram
1576-3A Power Supply
Dwg. # 1576W3A

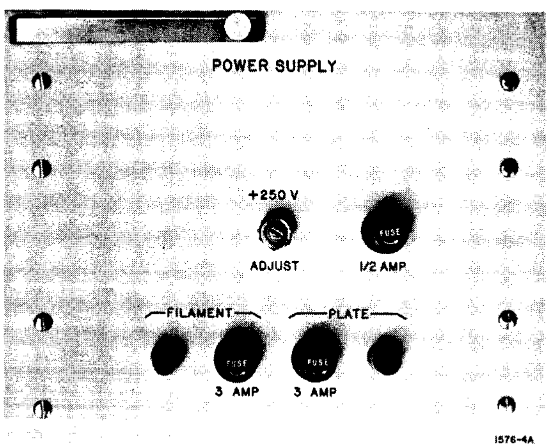
POWER SUPPLY
MEC MODEL 1576-4A

1. GENERAL DESCRIPTION

The +250volt, 250ma Power Supply has two outputs, +250volt and 12.6vac, center tapped, which is capable of furnishing 7 amperes to external filament circuits. The primary windings of transformers T401 and T402 are tapped to compensate for high or low line voltage. If the line voltage is predominantly high, (125 volts or greater) the taps should be moved from terminal 3 to terminal 4. If the line voltage is low, (105 volts or less) the taps should be moved from terminal 3 to terminal 2. An amber indicator, DS402, labeled FILAMENT and a red indicator, DS401, labeled PLATE indicate that transformers T402 and T401 have been energized. Input and output fuses and a +250volt adjust potentiometer R423 are provided. The output of transformer T401 is full-wave recitifed by silicon diodes CR401 through CR408, filtered by inductor L401, capacitors C401-C403 and applied to the plates of series regulator tubes V401-V403, which furnish a regulated output of +250volts. Resistors R401 and R402 insure equal division of voltage between capacitors C402 and C403.

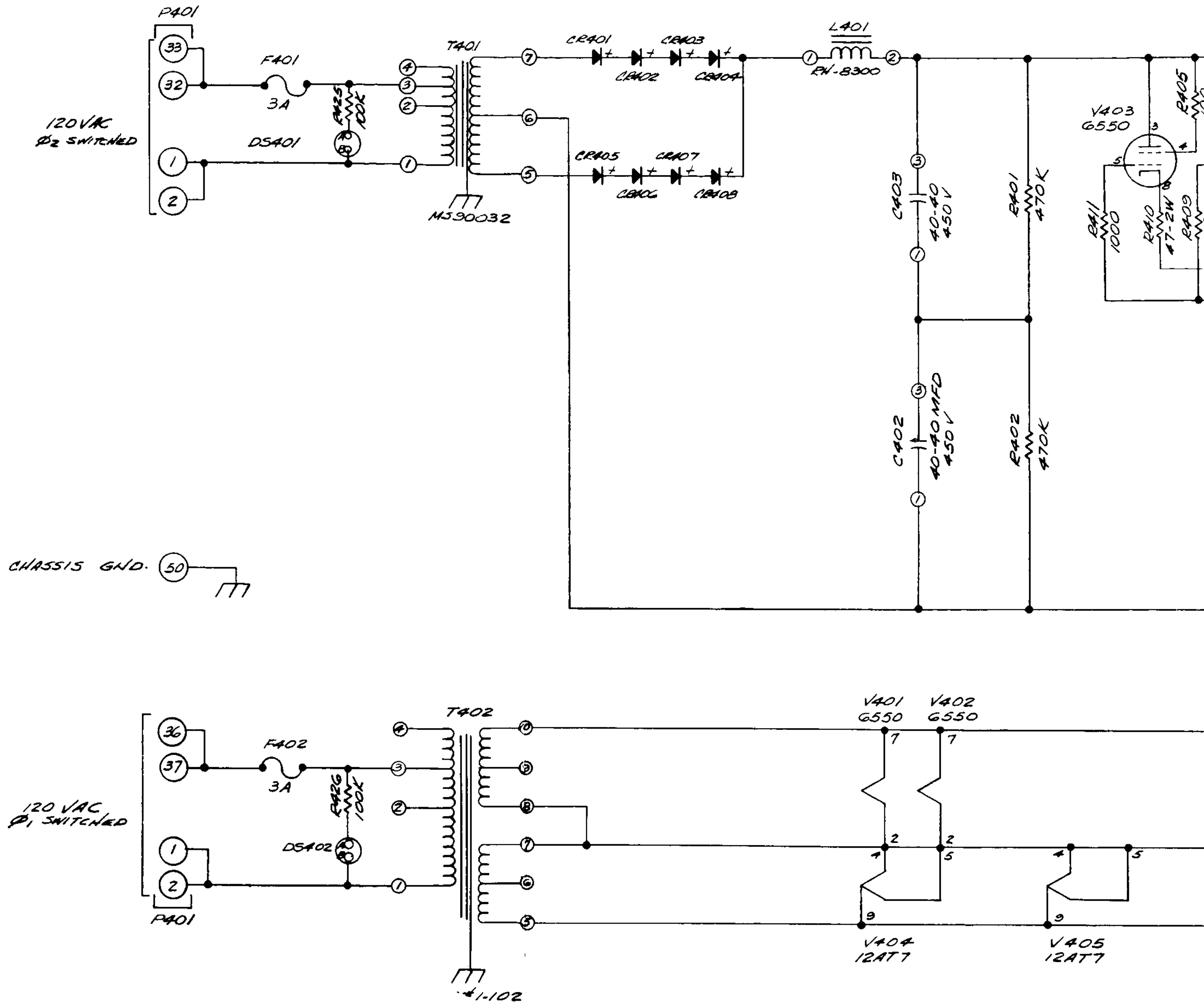
2. DETAILED DESCRIPTION

The -250volts generated by the -250volt regulator section of the -250volt Power Supply is applied to a resistor divider consisting of resistors R422, R423 and R424. This resistor string compares the +250volt output to the -250volt output. The error voltage appearing on the wiper of potentiometer R423 is amplified by tube V405 and directly coupled to amplifier tube V404 which in turn drives the grids of the three series regulator tubes V401-V403. If the +250volt output increases, becoming more positive, the pin 6 plate of V405 becomes more negative, and the pin 1 plate of V405 becomes more positive, causing the plates (pin 1 and 6 of V404), to become more negative This causes the grids of three regulator tubes to become mbre negative, and since the regulators act essentially as cathode followers, their cathodes also become more

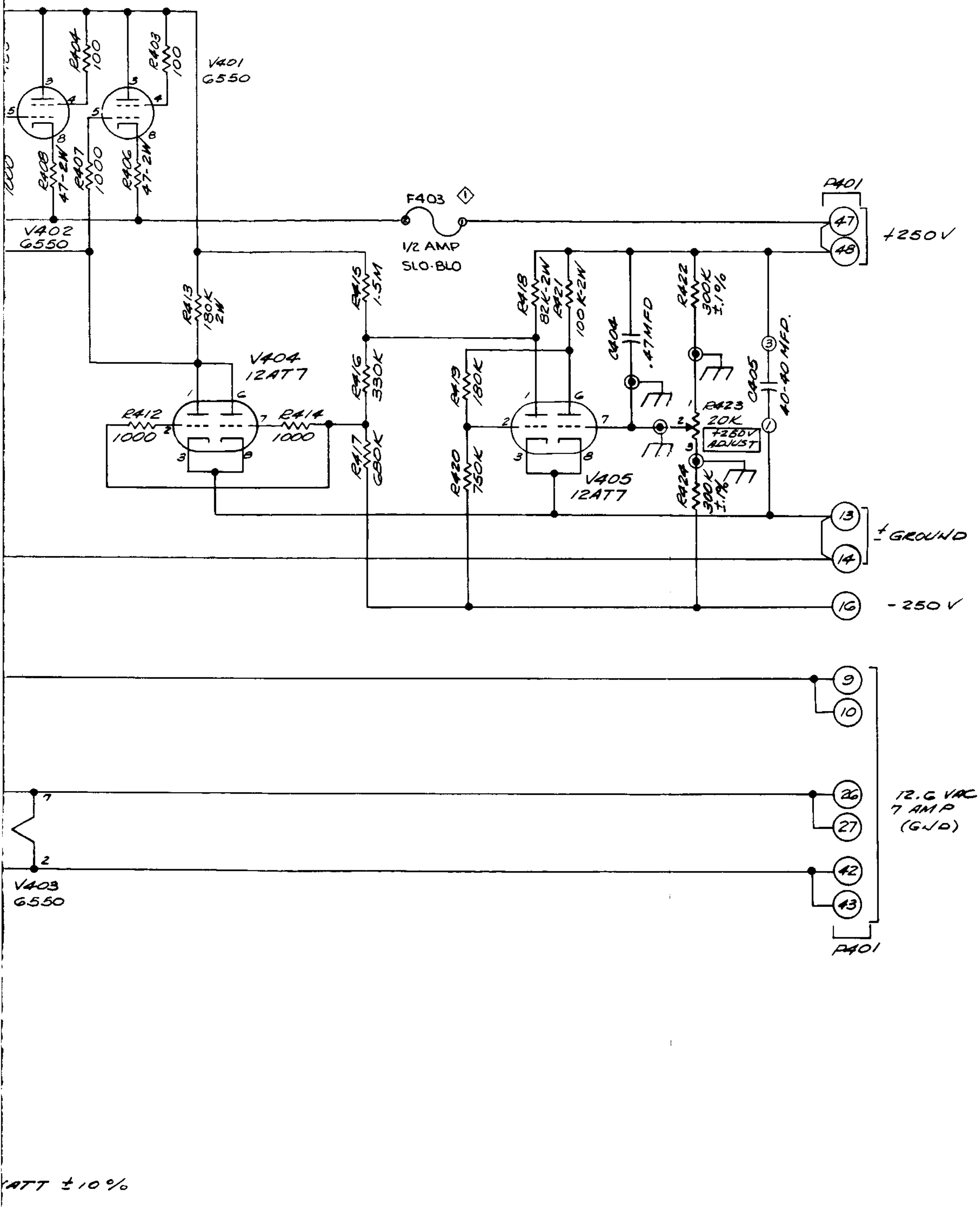


MEC Model 1576-4A Power Supply

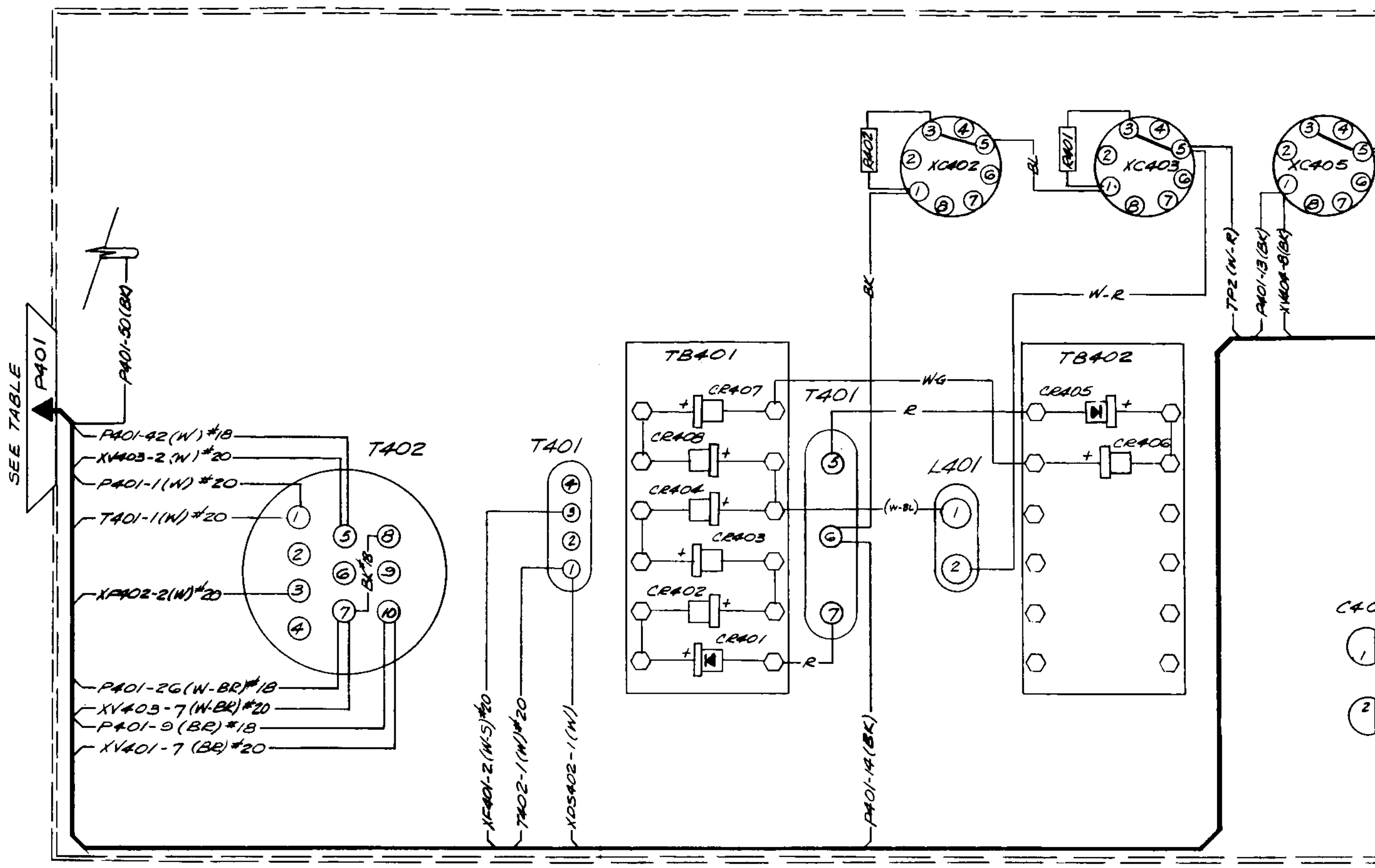
negative, thereby reducing the output voltage. Similarly, if the output voltage were to go negative, the grids of the three regulator tubes would go positive tending to cause the output voltage to remain constant. Should a change occur in the -250 volt power supply voltage, the +250 volt supply will change proportionally due to the resistor divider R422, R423 and R424, thus keeping the supply voltages to the DC amplifiers balanced.



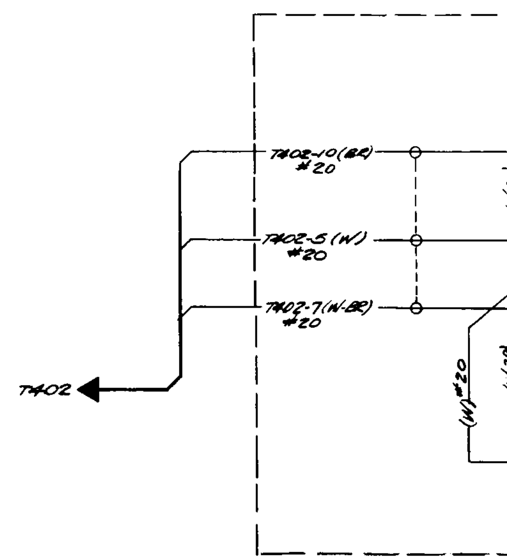
NOTES:
1. ALL RESISTORS ARE TO BE 1/2 W
UNLESS OTHERWISE SPECIFIED.
2. CR401- CR408 ARE TO BE 1N1695

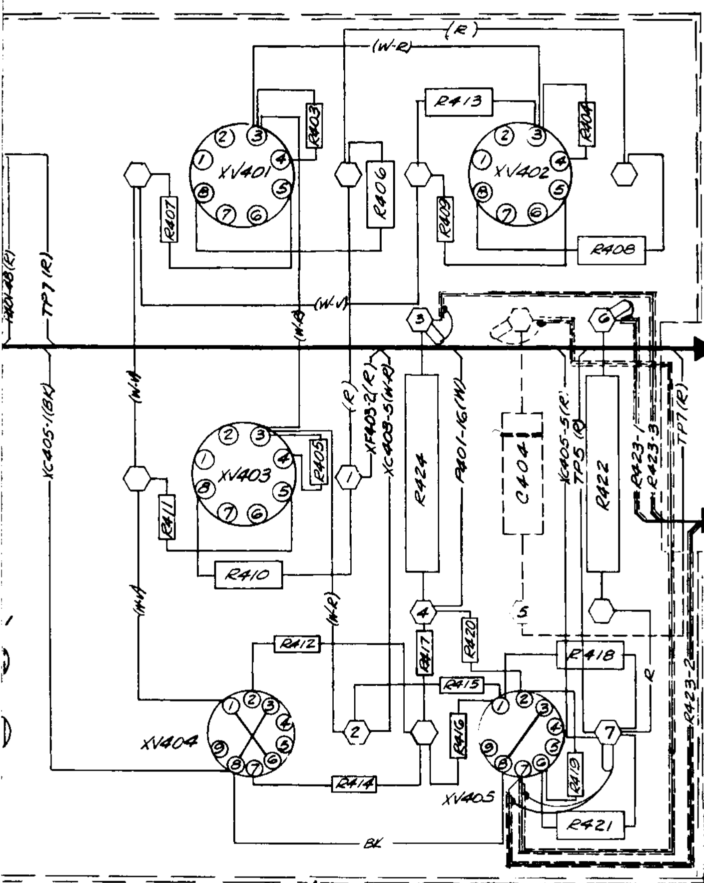


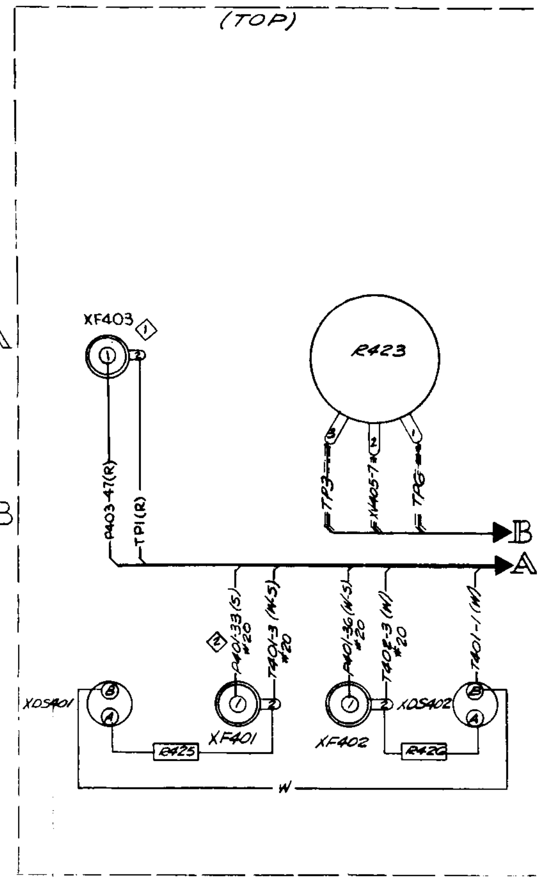
Schematic
1576-4A Power Supply
Dwg. # 1576S4A

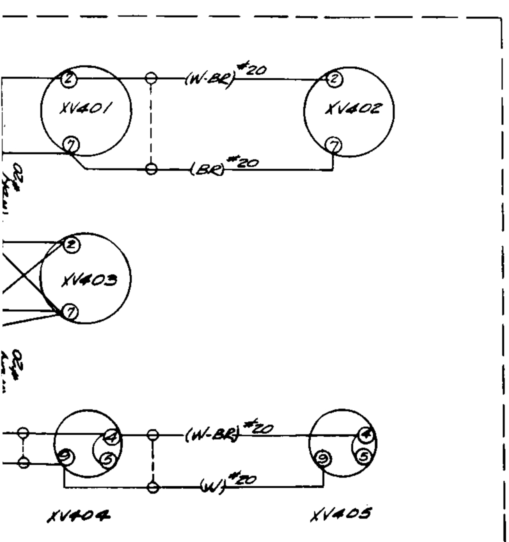


P401					
TERM	DESTINATION	FUNCTION	TERM	DESTINATION	FUNCTION
1	T402-1 (W) #20	120 VAC	26	T402-7(W-BR)#18	12.6VAC (CT)
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33	XF401-1(S)#20	120 VAC INPUT
9	T402-10(BR)#18	12.6 VAC	34		
10			35		
11			36	XF402-1(W-S)#20	120VAC INPUT
12			37		
13	XC405-1 (BK)	±GROUND	38		
14	T401-6 (BK)	±GROUND	39		
15			40		
16	TP4 (W)	-250V	41		
17			42	T402-5(W)#18	12.6 VAC
18			43		
19			44		
20			45		
21			46		
22			47	XF403-1 (R)	+250 VAC
23			48	XC405-5 (R)	+250 VAC
24			49		
25			50	GROUND LUG(BK)	CHASSIS GND









FILAMENT WIRING

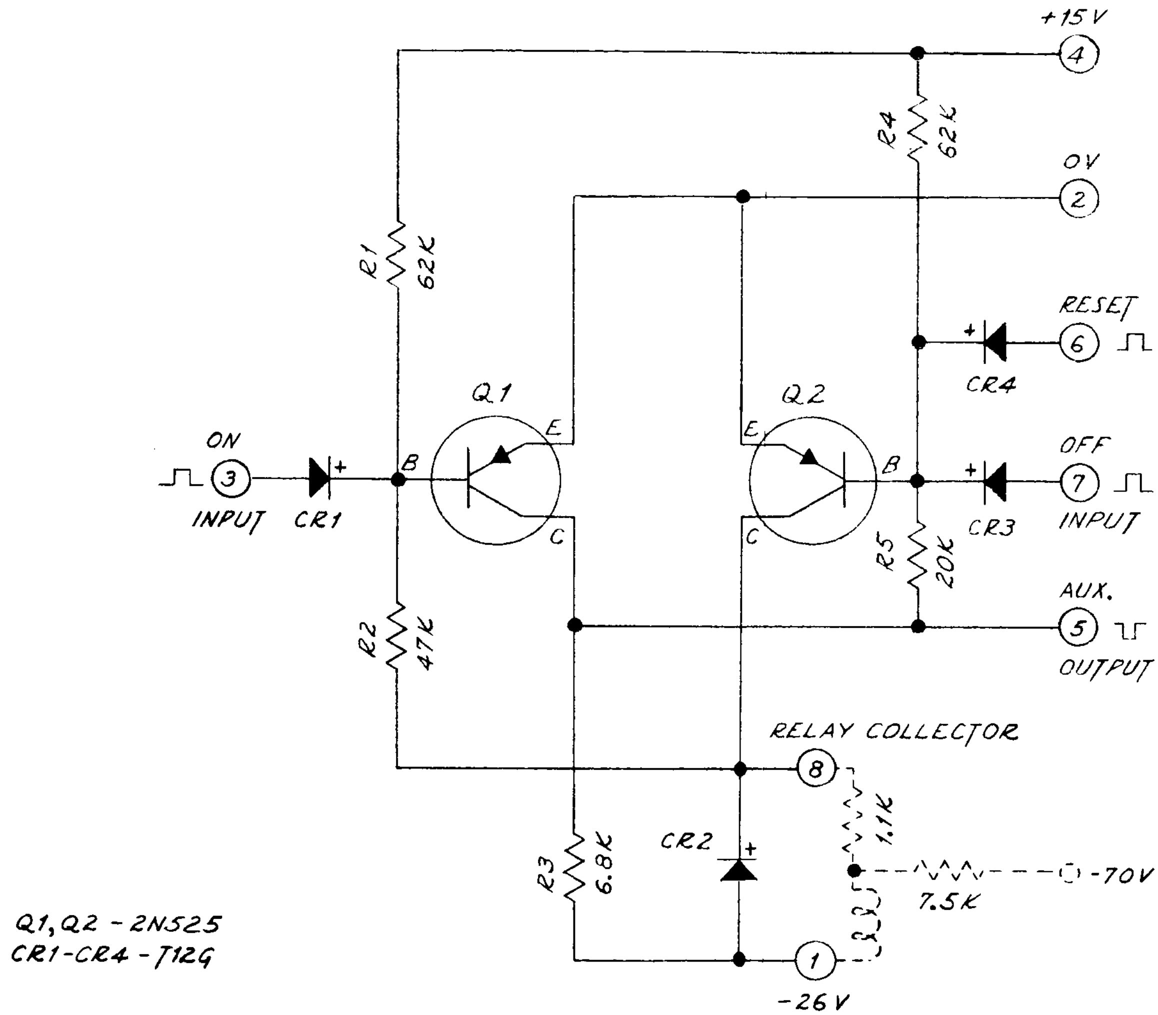
NOTES:

1. ALL WIRE TO BE #22 GA. UNLESS OTHERWISE SPECIFIED
2. INDICATES RG174/U COAX.
3. (1) INDICATES TIE POINT
4. o——o INDICATES TWISTED LEADS.

Wiring Diagram
1576-4A Power Supply
Dwg. # 1576W4A

TN 28
RELAY DRIVING FLIP-FLOP

A TN28 is a bistable flip-flop which can be used for driving a relay coil or other loads of 500 ohms or more. The external load (shown on the schematic diagram in phantom between pins 8 and 1) is a special network used in conjunction with a 350 ohm relay coil which has permanent magnet bias and requires plus and minus currents for optimum operation. The network is normally defined as being in the "off" or "0" condition when transistor Q1 is saturated and Q2 is cut off, leaving the relay de-energized. The "on" or "1" condition is the opposite, with Q1 cut off and Q2 saturated, causing the relay to energize. Assuming that Q1 is saturated, then its collector is approximately -0.25 volts. Resistors R4 and R5 are then connected from +15 volts to 0 volts and by divider action hold the base of Q2 at approximately +3.5 volts. Since the emitter at Q2 is at 0 volts, this reverse bias keeps Q2 cut off. With Q1 saturated, its base is at approximately -.05 volts; so the current through resistor R1 is approximately 0.25 milliamps. The current through the series combination of R2 and the external load resistor, which may very from 500 ohms to 5K, varies from 0.53 to 0.48 milliamps. The difference between the currents in R1 and R2 is the base current of Q1, which is sufficient to drive Q1 to saturation. This satisfies the original condition, so this condition is a stable one. The input voltages at pins 3, 6 and 7 must be somewhat negative during quiescent conditions. The flip-flop may be turned "on" by raising the voltage at pin 3 to a positive value so that diode CR1 conducts, raising the base voltage of Q1 to a positive value. Note that the input pulse will be loaded somewhat, so it cannot be generated by a high impedance source. With the base of Q1 positive, Q1 is now reverse biased and cut off. With Q1 cut off, R4 and R5 are no longer connected between 0 and +15 volts, and Q2 is no longer clamped off. Instead, Q2 base current may now flow through resistors R5 and R3, causing Q2 to saturate. Now resistors R1 and R2 are connected from +15 to 0 volts and hold the base of Q1 at approximately +6 volts, keeping Q1 in a cut off condition after the input pulse passes. This, then, is the other stable condition which will be maintained until Q2 is cut off by a positive pulse at either pin 6 or pin 7. A positive pulse at either of these pins turns Q2 off, allowing base current from Q1 to be conducted through R2 and the external load, driving Q1 back into saturation and restoring the initial condition. Diode CR2 is included to suppress the voltage of an external relay coil connected across pins 8 and 1. As Q2 goes from saturation to cutoff, the relay coil is de-energized. However, the inductance of the relay coil attempts to maintain the current through the relay coil by driving the voltage at pin 8 much more negative than the -26 volt supply. If this were allowed to happen, Q2 could be damaged by excessive emitter-collector voltage. To prevent this from happening, diode CR2 is added. During most phases of the cycle, CR2 is reverse biased and so does not enter into the operation of the circuit. When the relay is de-energized and pin 8 is driven negative by the relay inductance, CR2 is forward biased and conducts, providing a path for current through the relay coil and eliminating the voltage spike. Although the description of operation of this network has been based on voltages of +15 volts and -25 volts, this network will operate equally on voltages of +12 volts and -20 volts or +10 volts and -15 volts.



Schematic,

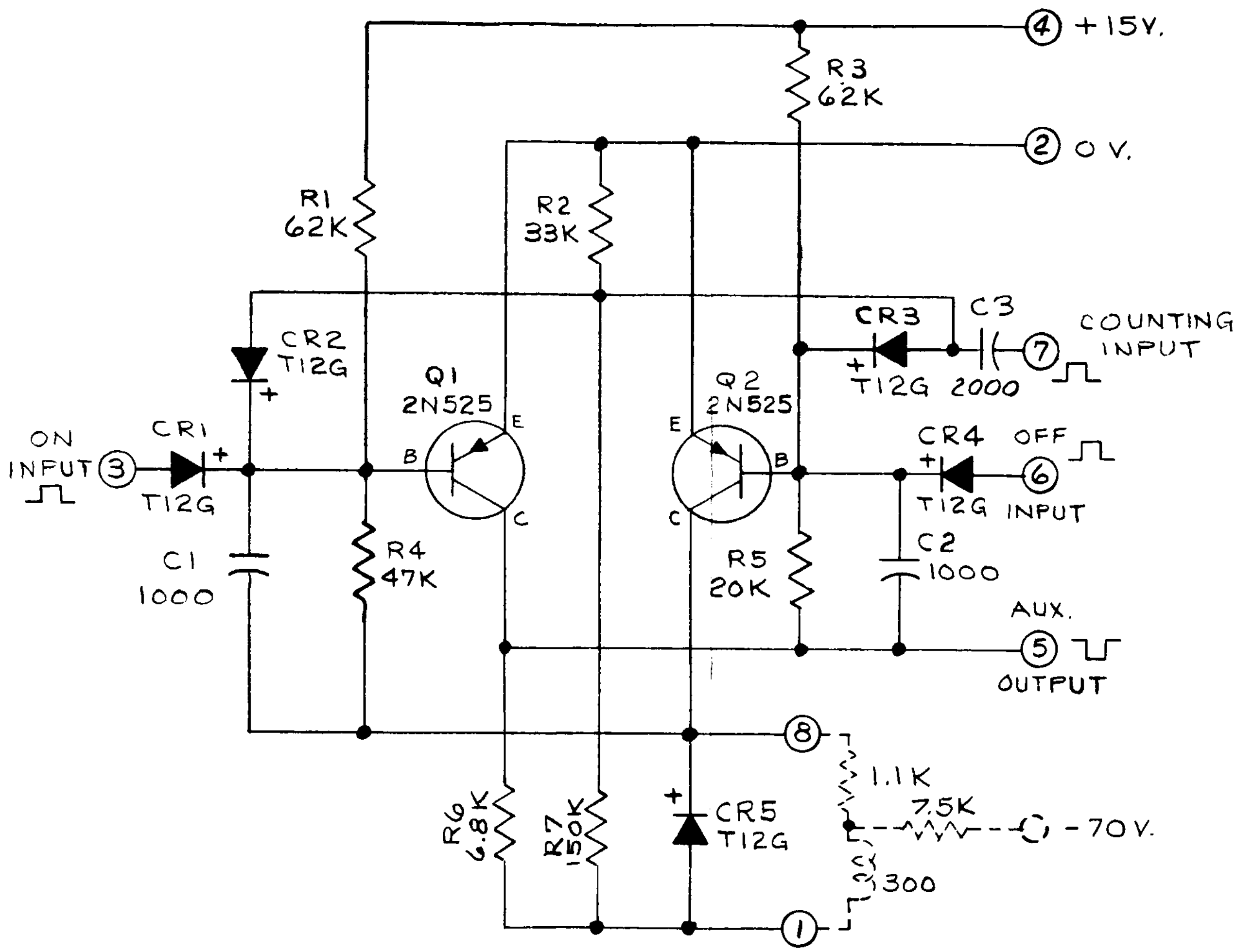
TN28 Relay Driving Flip-Flop

Dwg. #A103S28A

TN 42
RELAY DRIVING COUNTING FLIP-FLOP

TN42 is a counting type bistable flip-flop which can be used to drive a relay coil or other loads 500 ohms or more. The external load which is shown on the schematic diagram as dotted between pins 8 and 1 is a special network used in conjunction with a 350 ohm relay coil which has permanent magnet bias and requires plus and minus currents for optimum operation. The network is normally defined as being in the "off" condition when transistor Q1 is saturated and Q2 is cut off leaving the relay de-energized. The "on" or "1" condition is in the opposite, with Q1 cut off and Q2 saturated causing the relay to energize. If we assume that Q1 is saturated then its collector will be at approximately -0.25 volts. Resistors R3 and R5 are then connected from +15 to 0 volts and by divider action hold the base of Q2 at approximately +3.5 volts. Since the emitter at Q2 is at 0 volts, this reverse bias will keep Q2 cut off. With Q1 saturated its base will be at approximately -0.5 volts so the current through resistor R1 is 0.25 ma. The current through the series combination of R4 and the external load resistor, which may vary from 500 ohms to 5K, will vary from 0.53 to 0.48 ma. The difference between the current in R1 and the current in R4 is the base current of Q1, which is sufficient to drive Q1 to saturation. This satisfies the original condition, so that condition is a stable one. The input voltages at pins 3 and 6 must be somewhat negative during quiescent conditions. The flip-flop may be turned "on" by raising the voltage at pin 3 to a positive value so that diode CR1 will conduct, raising the base voltage of Q1 to a positive value. It should be noted that the input pulse will be loaded somewhat so it cannot be generated by a high impedance source. With the base of Q1 positive, Q1 is now reverse biased and cut off. With Q1 cut off R3 and R5 are no longer connected between 0 volts and +15 volts and Q2 is no longer clamped off. Instead, Q2 base current may now flow through resistors R5 and R6 causing Q2 to saturate. Now resistors R1 and R4 will be connected from +15 to 0 volts and will hold the base of Q1 at approximately +6 volts, keeping Q1 in a cut off condition after the input pulse passes. This then is the other stable condition, which will be maintained until Q2 is cut off by a positive pulse at pin 6. A positive pulse at pin 6 will turn Q2 off, allowing the base current from Q1 to be conducted through R4 and the external load, driving Q1 back into saturation and restoring the initial condition. Diode CR5 is included to suppress an external relay coil connected across pins 8 and 1. As Q2 goes from saturation to cut off the relay coil is de-energized. However, the inductance of the relay coil will attempt to maintain the current through the relay coil by driving the voltage at pin 8 much more negative than the -26 volt supply. If this were allowed to happen Q2 could be damaged by excessive emitter-collector voltage. To prevent this from happening, diode CR5 is added. During most phases of the cycle CR5 will be reverse biased and therefore will not enter into the operation of the circuit. But when the relay is de-energized and pin 8 is driven negative by the relay inductance, CR5 is now forward biased and conducts, providing a path for current through the relay coil and eliminating the voltage spike.

The actions just described cover the operation of this network as a conventional bi-stable flip-flop which requires a turn-on pulse and a turn-off pulse. In addition, this network can be used for counting by using the pin 7 input. R2 and R7 act as a divider network which establishes their junction at -4.5 volts. Since the bases of Q1 and Q2 are either at -0.5 volts or at a positive voltage, both CR2 and CR3 will normally be reverse biased and non-conducting. By applying a positive pulse approximately 10 volts high with a rise time of approximately 0.5 microseconds to pin 7, the junction of R2 and R7 will be raised to +5.5 volts until C3 discharges. This will permit both CR2 and CR3 to conduct, which will cut off both Q1 and Q2 simultaneously. Assume the condition before the input pulse was Q1 saturated and Q2 cut off. When both are cut off by the input pulse there will be no drop in voltage at the collector of Q2, hence no pulse coupled through C1. But when Q1 cuts off the resulting drop in voltage at the Q1 collector is coupled through C2 to the base of Q2. The result is that when the input pulse has been differentiated (C3 charges up) and no longer has an effect, C2 forces Q2 to conduct. When the next positive pulse is applied to pin 7, the resulting drop in voltage at the Q2 collector will force Q1 to turn on first. In this way the state of the network will change from a "0" to a "1" or reverse for every positive pulse that is applied to pin 7.



Schematic,

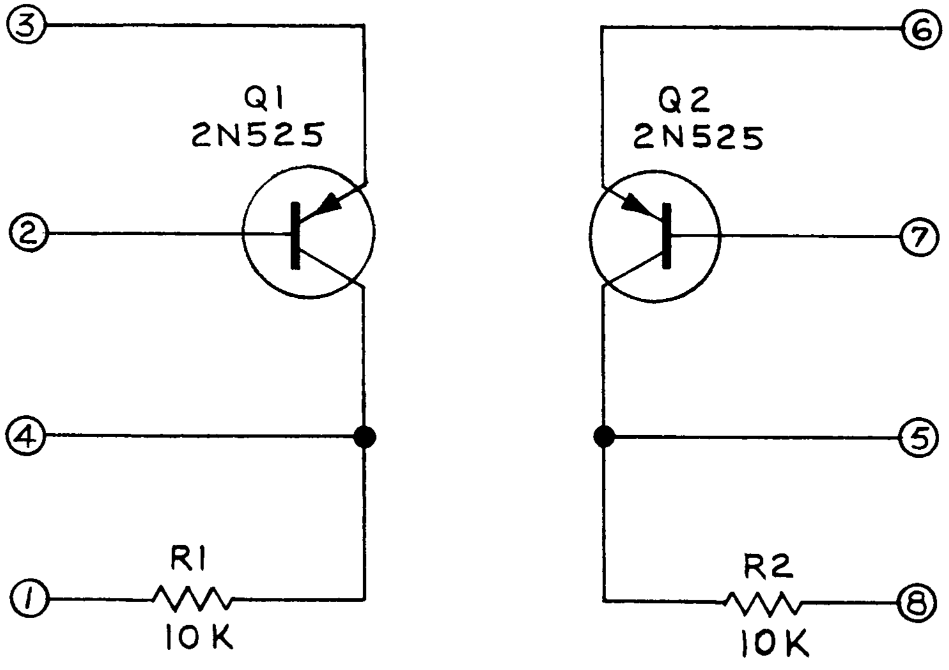
TN42 Relay Driving Counting Flip-Flop

Dwg. #A103S42A

TN 57
DUAL PULSE AMPLIFIER

The TN57 contains two PNP transistors connected as two independent conventional amplifiers. Only one of these will be discussed since the other is identical to it. As normally used, a supply voltage is connected to pins 3 and 1 with the plus side on pin 3. Pin 2 will be the input and pin 4 the output. As long as pin 2 is more positive than pin 3 the transistor is cut off and the voltage at pin 4 will be the same as the voltage at pin 1. When pin 2 is approximately 0.5 volts negative with respect to pin 3 the transistor will saturate and the voltage at pin 4 will go positive until it saturates, approximately 0.25 volts more negative than the emitter. Caution must be used to connect an external base resistor in series with pin 3 to prevent damage to the transistor. The value of the external base resistor is dependent upon how negative the driving voltage goes and upon the external load that is connected to pin 4. To insure saturation the base current should be at least 1/20th of the collector current.

The TN57 may also be used in a variety of applications by the addition of external components.



Schematic

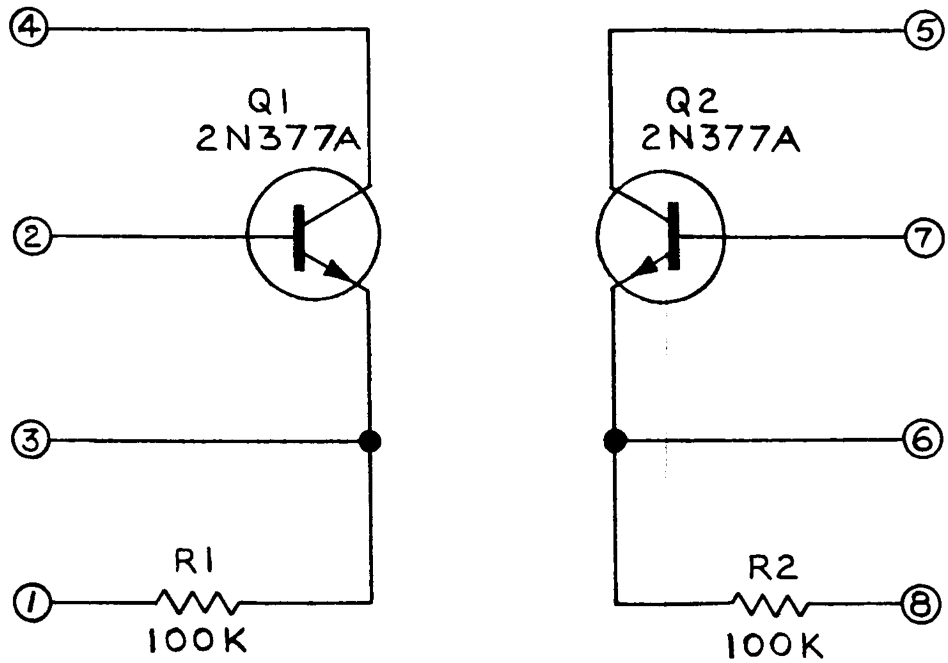
TN57 Dual Pulse Amplifier

Dwg. #A103S57A

TN 58
DUAL EMITTER FOLLOWER

A TN58 consists of two NPN transistors connected as independent emitter followers. As normally used, a supply voltage is connected to pins 4 and 1 with the plus side on pin 4. As the voltage at pin 2 is varied, between the voltages at pins 4 and 1, the transistor will conduct and the voltage at the emitter, pin 3, will be approximately 0.4 volts more negative than the voltage at pin 2. Because of the power gain of the transistor a lower impedance load can be driven from pin 3 than could have been driven from the signal applied to pin 2.

The TN58 may also be used in a variety of applications by the addition of external components.



Schematic

TN58 Dual Emitter Follower

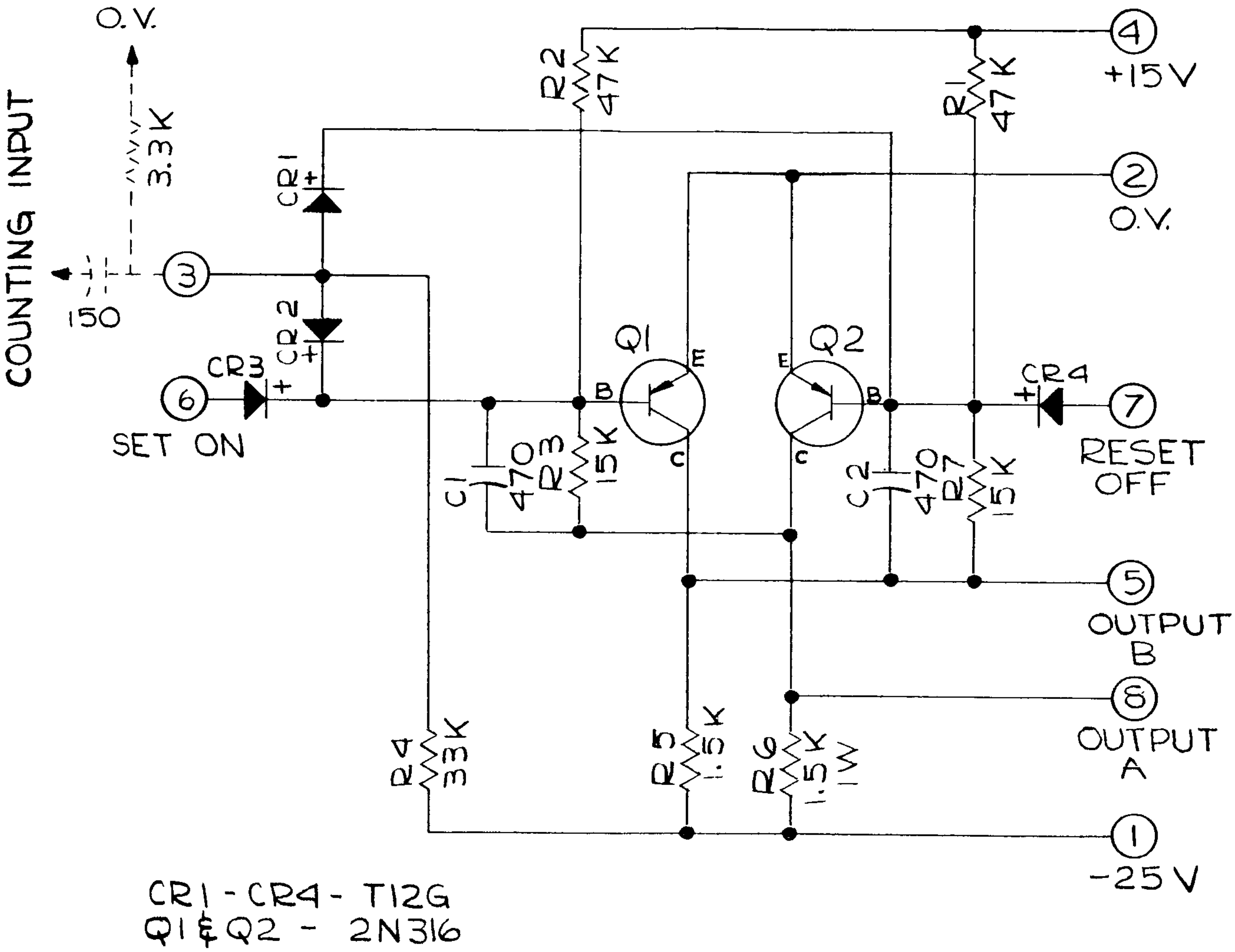
Dwg. #A103S58A

TN 90B

BALANCED FLIP-FLOP AND DIVIDER

The TN90B is a bistable balanced flip-flop. An auxiliary input (pin 3) allows the network to be used as a divider in a counter.

The network is defined as being in the "0" state when Q1 is saturated and Q2 is off and in the "1" state when the reverse is true. Assume that Q1 is saturated ("0" state) then the collector voltage of Q1 will be approximately 0 volts and resistor divider, R1 and R7, will maintain approximately +3.5 volts of reverse bias on the base of Q2, keeping it cut off. With Q2 cut off, resistors R3 and R6 will provide a path for Q1 base current, clamping Q1 in saturation. This condition is stable and will not be changed until an input is received on pin 3 or pin 6. Pin 6 is in "1" input, in that a positive pulse above 0 volts at pin 6 will cause CR3 to conduct, thus driving the base of Q1 positive above 0 volts, reverse biasing Q1, subsequently cutting Q1 off. As Q1 is cut off its collector will go negative and due to the resistor divider, R1 and R7, the base of Q2 will go negative. As the base of Q2 goes negative, Q2 will go into saturation. As Q2 saturates, its collector will go positive and due to the resistor divider of R2 and R3 the base of Q1 will be reverse biased at approximately +3.5 volts, keeping Q1 cut off, after the input pulse has passed. The network will remain in the "1" state until reset by a positive pulse on pin 7 or triggered from a pulse on pin 3, the counting input. If a positive pulse is applied on pin 3 through an external capacitor for differentiation, both Q1 and Q2 will be cut off. Capacitors C1 and C2 retain charges which are dependent upon which one of the transistors was saturated before the input pulse occurred. Since the input pulse is differentiated by a small input capacitor, it will last a very short time, less than one microsecond. At this point, the internal capacitors C1 and C2 take over, turning on the transistor that had previously been off. For example; assume the network is the "1" state, therefore Q1 is cut off and Q2 is saturated. The voltage across C1 will be approximately 3.5 volts and across C2 will be approximately 26 volts. When pin 3 goes positive above 0 volts, both bases will be driven positive, cutting the transistors off. The collector of Q2 starts to go negative from 0 volts to -23 volts. Since this occurs almost instantaneously and C1 has been charged only 3.5 volts the base of Q1 will go negative, turning Q1 on. As Q1 is turned on, Q2 is held cut off and we are now in the "0" state as explained previously. Note, since the collector of Q1 was at -23 volts before the pulse occurred on pin 3 and there wasn't any change of collector voltage when the pulse did occur. The base of Q2 would not experience any change through C2. The output pins of the network are 5 and 8. When the network is in the "0" state pin 5 will be at 0 volts and pin 8 will be approximately -23 volts and the reverse is true when the network is in the "1" state. Although the description of operation has been based on voltages of +15 volts and -25 volts this network will operate equally on voltages of +12 volts and -20 volts or +10 volts and -15 volts.



Schematic,

TN90B Balanced Flip-Flop and Divider

Dwg. #A 103S90B

TN 130 B
CORE DRIVER

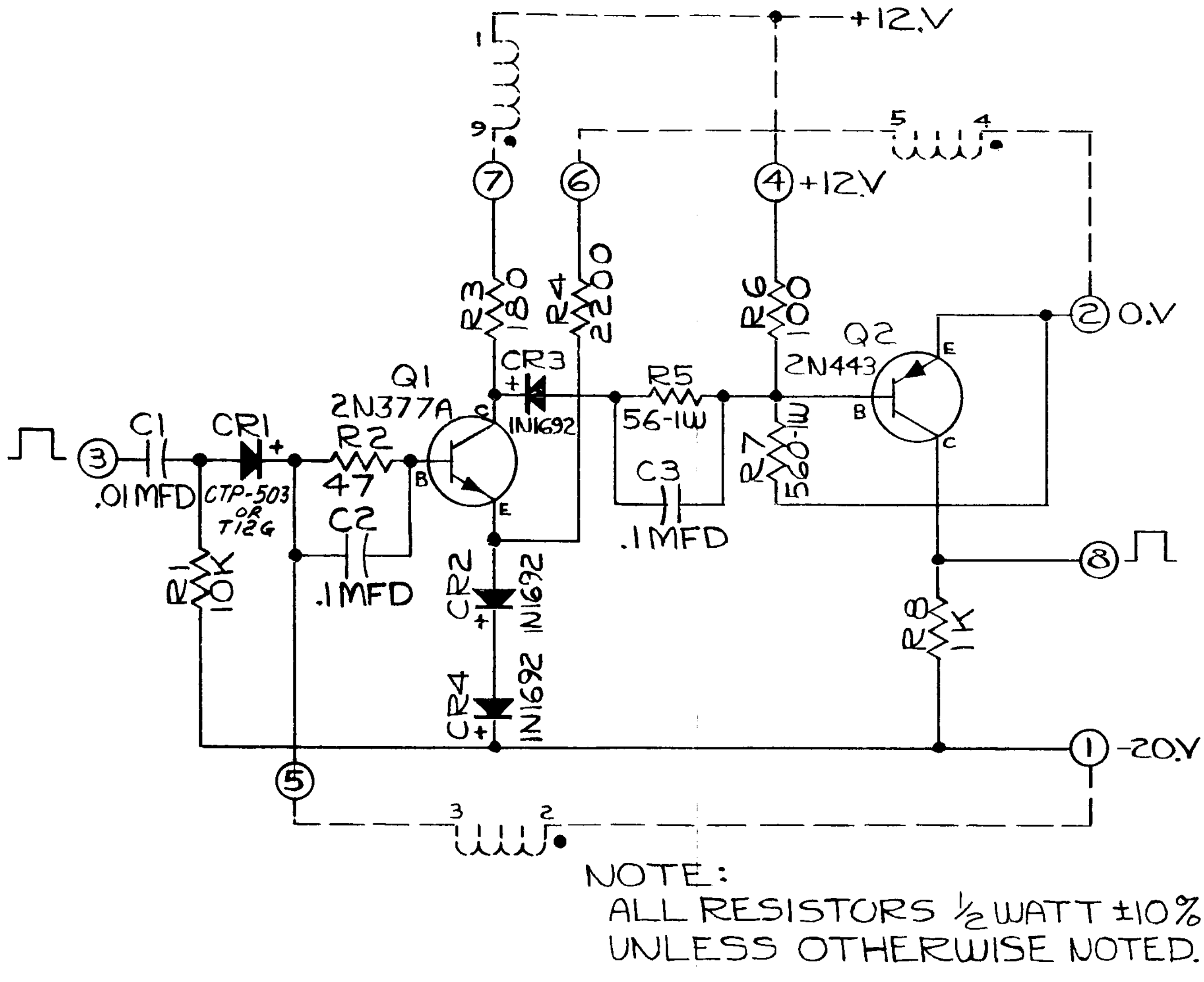
The TN130B is a blocking oscillator with amplifier which generates a positive going pulse from -20 volts to 0 volts, with a time duration determined by the core with which it is used. The TN130B is normally used with a MEC Model MN13 core, which gives it a pulse width of approximately 40 microseconds.

In the quiescent condition, transistor Q1 is maintained in cut off. The emitter voltage of Q1 is determined by the forward voltage drop of diodes CR2 and CR4 (1.5 volts) and is at approximately -18.5 volts. The base of Q1 is returned to -20 volts through R2 and the feedback winding of the core, connected from pin 5 to -20 volts. The d-c impedance of the feedback winding is approximately 5 ohms; thus the base of Q1 is nearly -20 volts, keeping Q1 reverse biased approximately 0.7 volts and properly cut off. Since there is no Q1 collector current, the collector voltage is +12 volts.

A positive going input pulse at pin 3 is coupled by capacitor C1, diode CR1, and capacitor C2, paralleled with R2 to the base of Q1. This pulse starts Q1 conducting. The resulting Q1 collector current passes through the collector winding of the external core. This generates a voltage across the collector winding coupled through the core to the feedback winding. By noting the phasing of the windings on the core, it can be seen that, as the collector voltage becomes negative, the voltage at pin 5 is becoming positive. This in turn drives Q1 further into conduction, even after the input pulse has been differentiated by C1. Q1 saturates in approximately one microsecond with an emitter-collector voltage of approximately 0.25 volts. Q1 will remain saturated as long as transformer action in the core continues to drive pin 5 of the TN network sufficiently positive to cause Q1 base current to flow. The pulse width (approximately 40 microseconds for an MN13 core) is determined by the characteristics of the core.

When the core material finally reaches saturation, transformer action in the core will cease, the feedback winding will no longer drive pin 5 positive, and Q1 base current will stop. This cuts off Q1. With no current in the collector winding of the core, the current in the reset winding resets the core. This reset current is furnished to the reset winding (pins 4 and 5 of the core) through resistor R4 and diodes CR2 and CR4. This involves going from the plus saturation condition attained during the output pulse to a minus saturation condition (reset). During this time, the voltages at the feedback winding and the collector winding are reversed. The reversal of a voltage at the feedback winding increases the reverse bias on Q1. The reversal of voltage in the collector winding tends to drive the output voltage somewhat more positive than the +12 volts on pin 7. It takes approximately 30 microseconds for the reset action to be accomplished.

The amplifier section Q2 is normally biased to cutoff by voltage divider R7 and R6. With no collector current flowing, the quiescent collector voltage of Q2 is -20 volts. The negative going pulse generated by the blocking oscillator section is coupled to the amplifier base through CR3, R5, and C3. The diode provides for rapid cut off of the amplifier, thereby minimizing the fall time. R5 and C3 serve as base current limiting and rise time determinants. The load is connected between -20 volts and 0 volts and should be limited to no less than 8 ohms (20 to 24 MN11 cores).



Schematic,

TN130B Core Driver

Dwg. #A103S130B

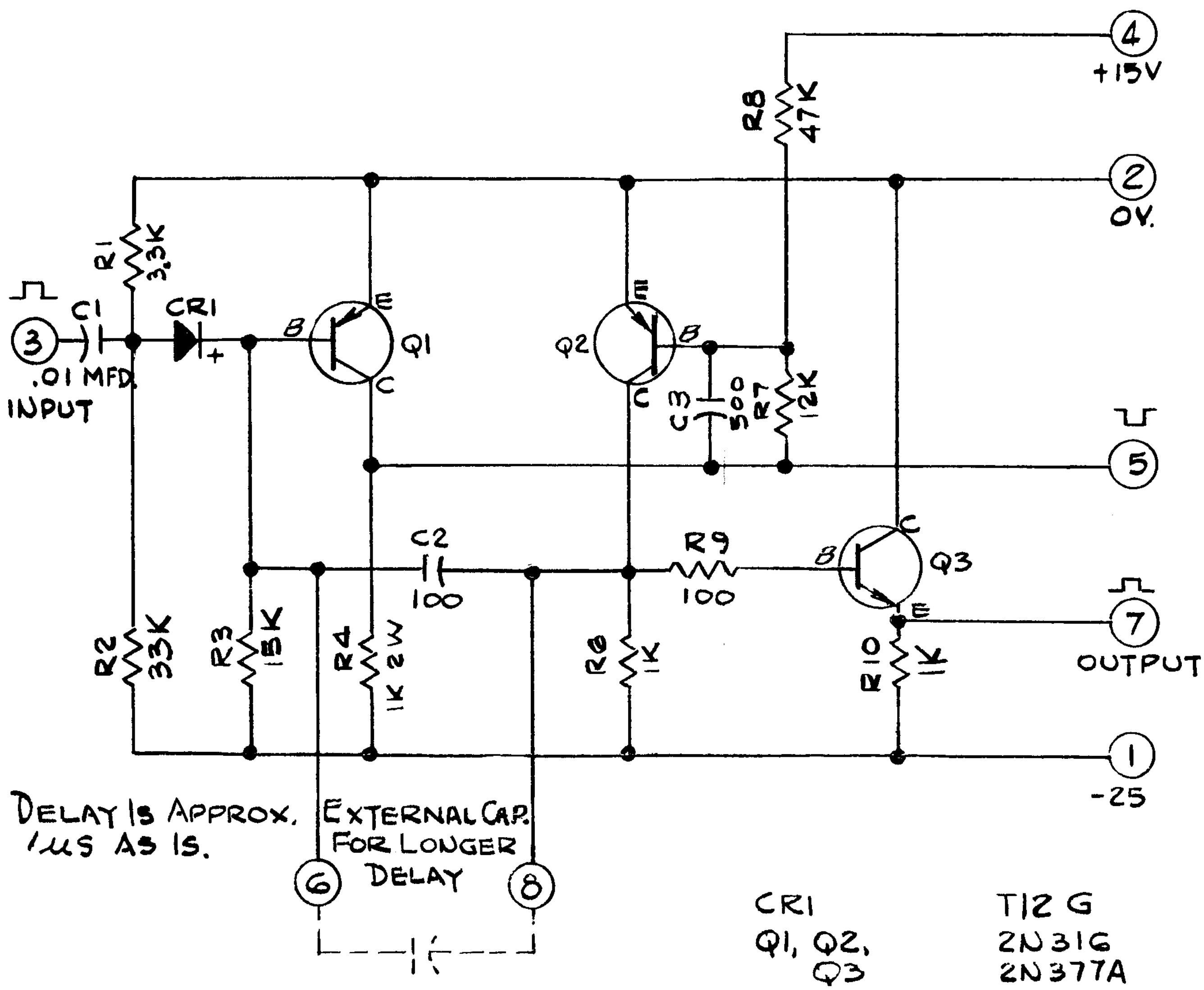
TN 138 B
ONE-SHOT WITH EMITTER FOLLOWER OUTPUT

The TN138B is a one-shot (monostable multivibrator) with an emitter follower output. This network can drive low impedance loads because of the emitter follower output.

The network's quiescent state is with Q1 saturated and with Q2 cut off. The base of Q1 is forward biased by R3 which is connected to -25 volts, thus saturating Q1. Since Q1 is saturated, the base of Q2 is reverse biased by the voltage divider R7 and R8 between +15 volts and the collector of Q1 (0 volts). With Q2 cut off, its collector is at approximately -25 volts; therefore the base of Q3 is at the same voltage as the emitter of Q3, keeping Q3 near cut off. Pin 7 will be at -25 volts and pin 5 will be at 0 volts. The resistor divider of R1 and R2 will maintain a reverse bias on diode CR1 of approximately 2.2 volts for protection against noise impulses. When a positive pulse of sufficient amplitude is applied to pin 3 to cause conduction of CR1, transistor Q1 will be cut off. The collector of Q1 will therefore go negative toward -25 volts. This negative going voltage potential is coupled to the base of Q2 through C3 and R7. This will cause the base of Q2 to go negative with respect to the emitter. Q2 will now conduct, and starts to saturate rapidly. The collector of Q2 will now go positive from -25 volts to 0 volts. This voltage change, being coupled through C2 to the base of Q1, will keep Q1 cut off after the input pulse has passed. C2 has now been charged, and will start to discharge through R3. When C2 has discharged sufficiently to allow the base of Q1 to return to its quiescent negative potential, Q1 will saturate. As Q1 saturates, its collector will go positive. Due to the resistor divider of R7 and R8, the base of Q2 will also go positive, reverse biasing Q2 and cutting it off. The one-shot has now returned to its quiescent condition.

The time constant of R3 and C2 determines the pulse width, which is about 1 microsecond. By adding external capacity across pins 6 and 8, the RC time constant is increased and thus the pulse width is increased. When Q2 is saturated, the base of Q3 will be positive in respect to the emitter, and this will cause Q3 to go into saturation. Pin 7, the output of the emitter follower, will go to 0 volts. Q3 will be in saturation as long as Q2 is in saturation. When Q2 is cut off, Q3 will be near cut off, and pin 7 will return to -25 volts.

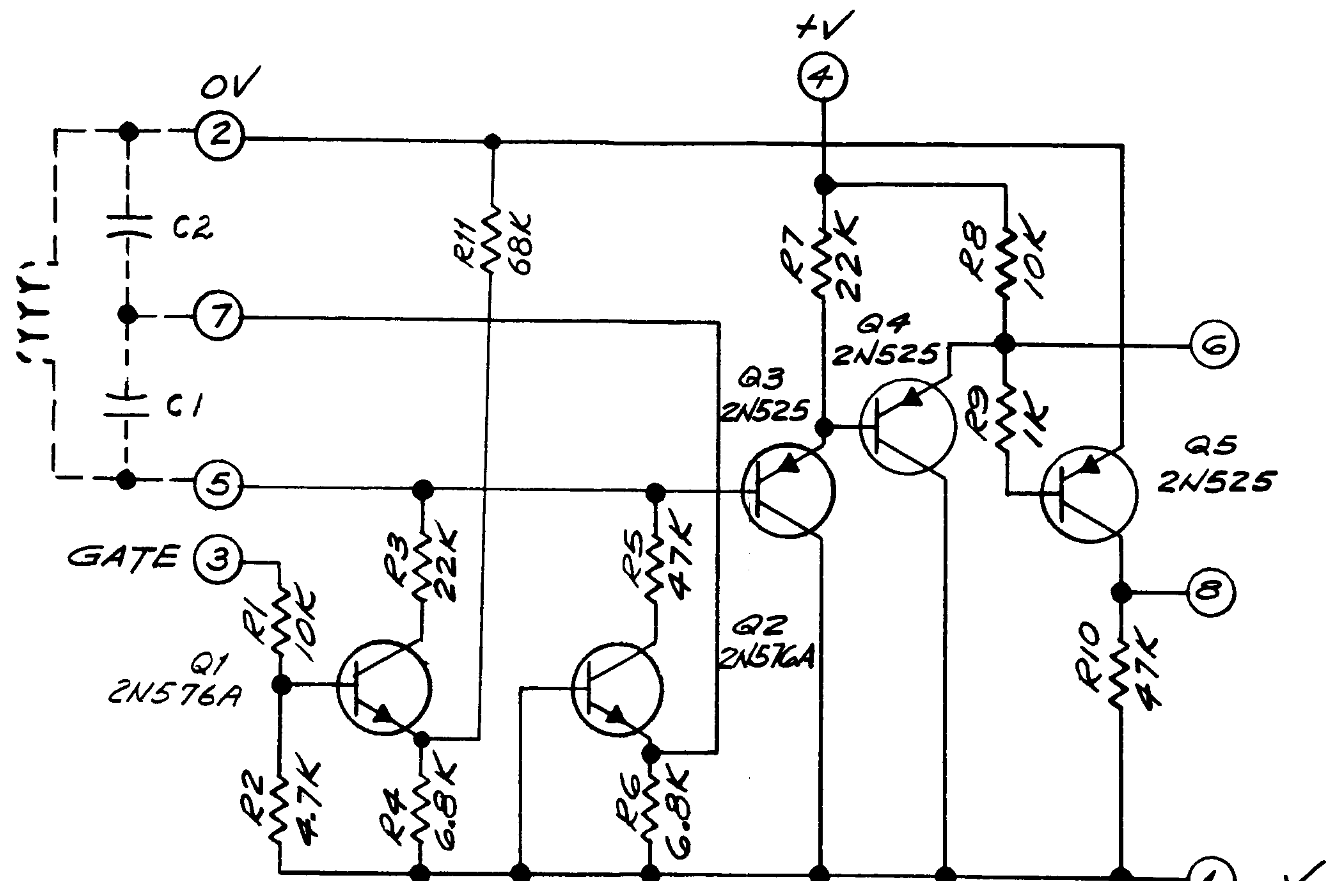
Although the description of operation has been based on voltages of +15 volts and -25 volts, this network will operate equally on voltages of +10 volts and -15 volts.



Schematic,

TN138B One-Shot with Emitter Follower Output

Dwg. #A103S138B



NOTES:
VOLTAGES +V +10 +12 +15
−V −15 −20 −25
C1:C2 = 1:10
ALL RESISTORS ARE 1/2 WATT UNLESS OTHERWISE SPECIFIED.

Schematic
TN134 Gated Oscillator and Squaring Circuit
Dwg.# A103S134A

TN 134
GATED OSCILLATOR AND SQUARING CIRCUIT

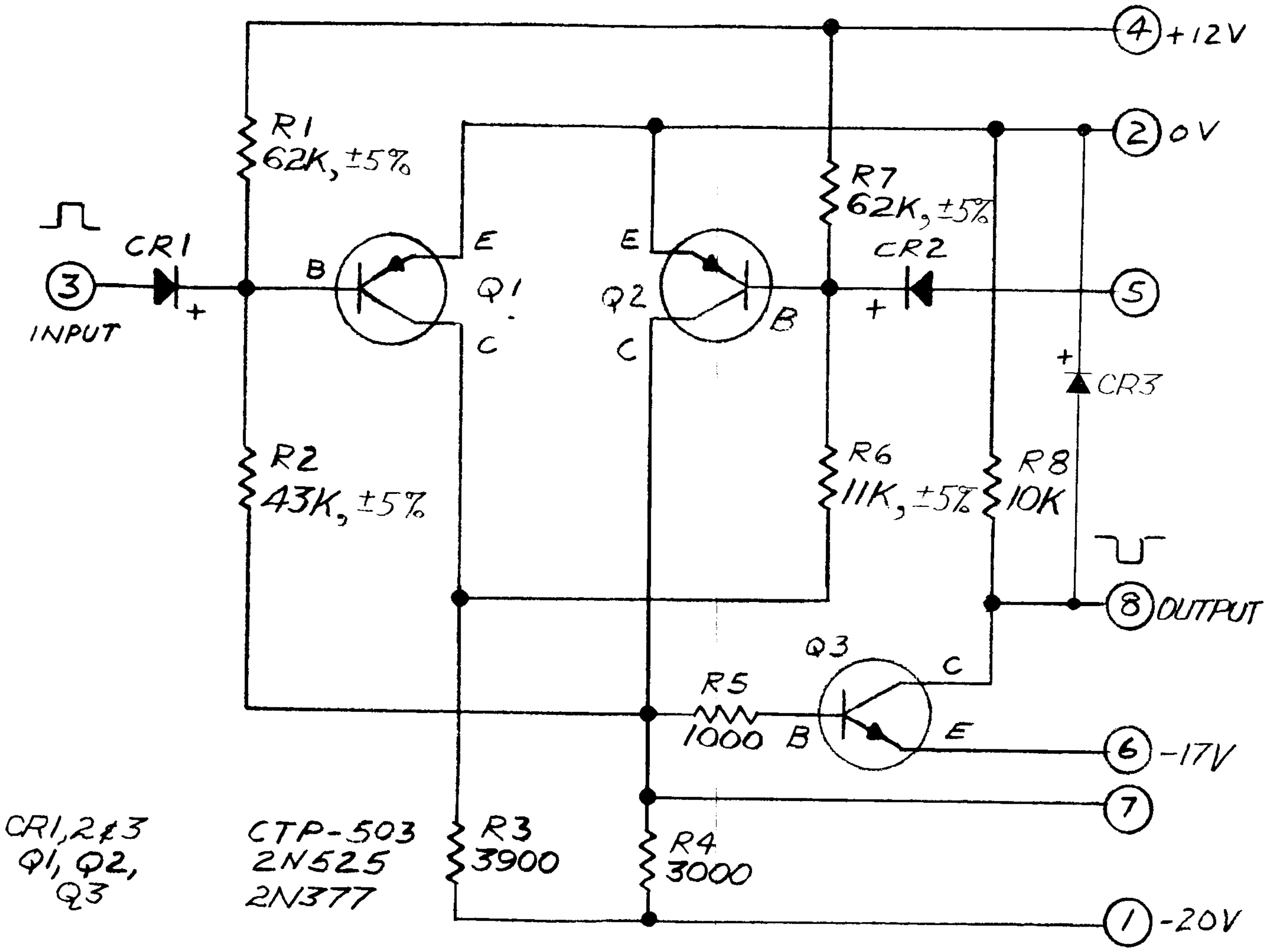
The TN134 is a gated oscillator (80 cycles to 5 kilocycles per second), which can be turned on or off by an external switching circuit. The oscillator section (Q2) is followed by two emitter-followers (Q3 and Q4) and one squaring amplifier (Q5), which amplify and clip the signal so the output is a square wave. The oscillator tank circuit consists of an external inductor, connected between pins 2 and 5, and external capacitors C1 and C2. The oscillator is turned on by clamping pin 3 to the minus supply voltage, and is turned off by clamping pin 3 between -1 volts and 0 volts.

When the voltage at pin 3 equals the minus supply voltage, the input transistor Q1 will be at cutoff and will have little or no effect on the oscillator transistor Q2. The base of Q2 is returned to a minus voltage, cutting off Q2 and sending the tank circuit into oscillation. The first half cycle of the tank curcuit applies a positive voltage to the junction of C1 and C2, keeping Q2 cut off. C1 and C2 will be partially charged during this positive going portion of the cycle by current through R6. As the oscillation in the tank circuit reverses, the junction of C1 and C2 tends to become negative, driving Q1 toward saturation, and pulling the tank circuit negative through pin 5. When Q2 saturates the junction of C1 and C2 is no longer driven negative and Q2 cuts off, starting the cycle over again.

The phasing of the drive into Q1 is such that the tank circuit is pulsed at the proper portion of its cycle to maintain oscillation. The voltage across the tank circuit, pin 5, is coupled to the base of emitter-follower Q3. Q3 drives another emitter-follower Q4. Q4, in turn, drives amplifier Q5 from cut off to saturation. The resultant waveform at the collector of Q5 is a square wave which goes from the minus supply voltage to approximately 0 volts at the same frequency as the oscillator. When the oscillator is switched off again by the pin 3 voltage approaching 0 volts, Q5 will saturate and the output will remain at 0 volts. The supply voltages may be -25 and +15 volts, -20 volts and +12 volts, or -15 and +10 volts.

TN 144
FLIP-FLOP WITH PULSE AMPLIFIER OUTPUT

A TN144 is a bistable flip-flop with a pulse amplifier output which can be used to drive a load of 85 ohms or more. Since most flip-flops are limited to the amount of loading, which affects the switching of the flip-flop, a pulse amplifier has been added to permit greater loads. A transistorized neon indicator may be connected in parallel with the load to indicate the states of the flip-flop. The network is normally defined as being in the "0" state when transistor Q1 is saturated and Q2 and Q3 are cut off. The "1" state is the condition when Q1 is cut off and Q2 and Q3 are saturated. Assuming that Q1 is saturated ("0" state), then its collector is at approximately -0.25 volt. Resistors R7 and R6 are then connected from +12 volts to 0 volts, and by divider action hold the base of Q2 at approximately +1.8 volts. Since the emitter of Q2 is at 0 volts, this reverse bias keeps Q2 cut off. With Q1 saturated, its base is at approximately -0.5 volt, so the current through resistor R1 is approximately 0.2 milliamps. Since Q2 is cut off, its collector is at approximately -19 volts, and the current through R2 and R4 is therefore 0.4 milliamps. The difference between the currents in R1 and R2 is the base current of Q1, which is sufficient to clamp Q1 in saturation. This mode of operation is therefore stable. Q3 is cut off when Q2 is cut off, since the base of Q3 is at -19 volts, reverse biasing the emitter. Since Q3 is cut off, there is no collector current (except for leakage) and pin 8 is at approximately 0 volts. The input voltages at pins 3 and 5 must be somewhat negative during quiescent conditions. The flip-flop may be triggered to the "1" state by raising the voltage at pin 3 to a positive value so that diode CR1 conducts, thus raising the base voltage of Q1 to a positive value. Note that the input pulse will be loaded somewhat, so it cannot be generated by a high impedance source. With the base of Q1 positive, Q1 is now reverse biased and cuts off. With Q1 cut off, R7 and R6 are no longer connected between the +12 volts and 0 volts, and Q2 is no longer clamped off. Instead, base current of Q2 may now flow through resistors R6 and R3, cuasing Q2 to saturate. Now resistors R1 and R2 are connected from +12 volts to 0 volts, and clamp the base of Q1 at approximately +5 volts, holding Q1 in a cut off condition after the input pulse passes. As Q2 is saturated and its collector goes positive, the base of Q3 goes positive enough to allow Q3 to saturate. R5 limits the base current of Q3. As Q3 saturates, pin 8 (the output pin) goes negative to approximately -17 volts. R8 is the collector load resistor of Q3, to furnish a minimum collector current when there is no external load from pin 8 of the network to 0 volts. This is the other stable condition which will be maintained until Q2 is cut off by a positive pulse on pin 5. A positive pulse (normally called reset) on pin 5 will allow base current from Q1 to be conducted through R2 and R4, driving Q1 back into saturation and restoring the initial condition. Diode CR3 is included to suppress the inductive effects of an external relay coil (if used) connected across pins 8 and 2. As Q3 goes from saturation to cut off, the relay coil is de-energized. However, the inductance of the relay coil attempts to maintain the current through it by driving the voltage at pin 8 much more positive than 0 volts. If this were allowed to happen, Q2 could be damaged by the excessive collector-emitter voltage. During most phases of the cycle, CR3 is reverse biased; consequently, it does not enter into the operation of the circuit. When the relay is de-energized and pin 8 is driven positive by the relay inductance, CR3 is forward biased and conducts, providing a path for the current through the relay coil and eliminating the excessive transient voltage to appear on the collector of Q3.



Schematic,

TN144 Flip-Flop with Pulse Amplifier Output

Dwg. #A103S144A

MAGNETIC CORES

1. GENERAL

A component commonly used in digital data handling equipment is a magnetic core. The term magnetic core is usually applied to a small torroid composed of magnetic material which has high permeability and also high retention. This material will have what is called a square hysteresis loop, shown in Point A, Figure MN-1. Because of this square hysteresis loop, there are two stable energy states, which make the cores adaptable to digital circuits. Magnetic cores are commonly used for shift registers, "and" gates, "or" gates, and other logic circuits, in addition to their use as blocking oscillator transformers.

2. THEORY OF OPERATION

2-1. GENERAL

a. The action of a magnetic core can best be described by referring to the drawing of the hysteresis loop (Figure MN-1). The magnetomotive force, or ampere-turns, applied to the winding of a core is measured along the X axis. Magnetic flux density (gausses), or flux lines per square centimeter, is being measured along the Y axis. Once a core has been magnetized and had this magnetization reversed several times, the relationship between flux density and magnetomotive force is described by the hysteresis loop in Figure MN-1.

b. With no current going through any of the core windings, the flux density will be either at point D or at point H, depending upon the direction in which the core has most recently been saturated. If the core is assumed to be at point D on the hysteresis loop and ampere-turns are applied in the negative direction, the relationship between the flux density and the magnetomotive force will follow the line DE. If additional ampere-turns are applied in the negative direction, the core will go on to condition F, at which point saturation has occurred and additional ampere-turns of magnetomotive force will result in only a minor increase in flux level to point G.

c. If the current through the windings is now removed, the core will return to point H on they hysteresis loop. Even though there are no ampere-turns, there is still a flux density proportional to OH in the core. The characteristics of the core material are such that this

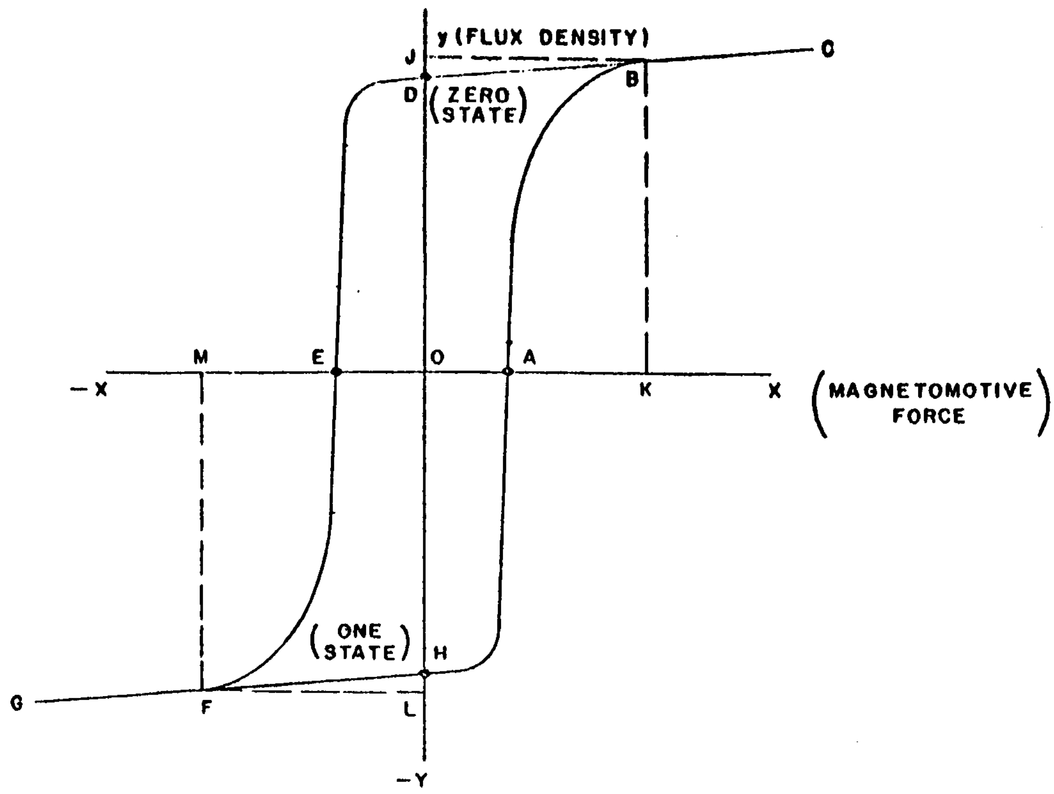


Figure MN-1. Square Hysteresis Loop

flux density will remain indefinitely as though it were a permanent magnetic. If the direction of current in the winding is reversed, positive ampere-turns are applied. This will move the condition of the core from H to A and on to B, at which point the core is now saturated in the positive direction and additional ampere-turns of magnetomotive force will cause very little change in flux density to point C. When the current in the coil is removed, the core will now go from C to D, where it will remain indefinitely until driven again.

d. The net change in flux, when going from a negative quiescent state to plus saturation, is proportional to HJ. It should be noted that other windings on the magnetic core will sense this change in flux and will generate a voltage proportional to the number of turns and the rate of change of flux. Figure MN-2 shows a simple magnetic core with three windings on it. If positive ampere-turns are then applied to winding No. 1, the core condition effectively goes from D to B. Since the hysteresis loop is very square, the change in flux during this time (proportional to DJ) is very small when compared to HJ. As a result, the voltage generated in coil No. 2 will be very small at this time.

e. If negative ampere-turns are again applied so that the core goes from D to E to F, the

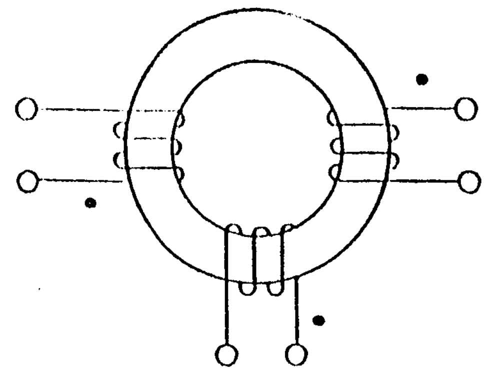


Figure MN-2. Simple Magnetic Core

change in flux will be proportional to DL. The voltage generated in winding No. 2 will now be equal in magnitude, but opposite in polarity, to the voltage generated in that winding when the core went from H to B. These pulses can be separated with diodes and used for different purposes in logic circuits. The two stable states, D and H, are referred to as the "0" state and the "1" state respectively.

2-2. MN11 MAGNETIC CORE

a. A Milgo MN11 magnetic core has four windings and associated components designed specifically for shift register application (Figure MN-3). Pin 7 is connected to a -25v supply. The core drive pulse, applied to pin 1, travels from -25v to approximately zero volts and return, with a rise time no greater than 5 microseconds and a fall time no greater than 10 microseconds. The pulse width must be at least 10 microseconds at 50 percent of measured points, but is normally approximately 40 microseconds wide.

b. This positive going pulse applied to pin 1 results in ampere-turns driving the core beyond positive saturation (Point C in Figure MN-1). When the core drive pulse has passed, the core is left in state D, which is defined as "O" state. The voltage at pin 8 is normally maintained at -25v but is raised to approximately -16v to insert a "1" into the core. It can be seen that the current in the input winding, as a result of a positive going pulse applied to pin 8, will magnetize the core in an opposite direction to that of the drive pulse. The state of the core will go from D to G on the hysteresis loop (Figure MN-1), and when the input pulse is passed, the core remains at H, which is defined as a "1" state.

c. When the next drive pulse occurs, the flux will travel from point H to Point C, and transformer action of the core and windings will result in a positive pulse being generated at the dot end of all four windings. This positive pulse will be approximately 9v in magnitude with a rise time of approximately 6 microseconds. Once the core has gone from negative saturation to positive saturation, there will be no more flux change even though the drive pulse is still present, and no additional voltage is generated in the windings. This switching time, which takes place in approximately 6 microseconds, determines the width of the pulse generated by the windings.

d. The 9v pulse generated in the advance winding causes diode CR3 to conduct, and will charge capacitor C3 to approximately -16v. After the core has switched to positive saturation, the voltage at pin 6 will revert to -25v. Diode CR3, however, prevents capacitor C3 from discharging through the advance winding, so the charge is held on C3 until it discharges through an external load.

e. During a core drive pulse, the voltage at pin 2 jumps from -25v to approximately zero volts because of the IR drop in R1 caused by the shift current. With pin 2 at approximately zero volts, diode CR2 will be reverse biased and no current can flow from pin 8 through CR2 and the input winding. After the core drive pulse has passed, the -16v charge on one CR3 can now discharge through CR2 and the input windings of the next core, driving it to the "1" state. A "1" can be inserted by raising pin 8 to -21v, or more positive. It should be pointed out that a "1" can also be inserted through pin 3, or by applying a pulse to pin 5, which becomes approximately 8v positive with respect to pin 4. If there is no "1" inserted between core drive pulses, the next core drive pulse will drive the core from point D to point C on the hysteresis loop, resulting in a very small change in flux density. This will result in a very small voltage being generated in the windings (approximately 0.5v), giving a signal-to-noise ratio of approximately 18 to 1.

f. It should be noted that energy transferred to a load while shifting out a "1" comes from the core driver and not from the core. The energy in the core merely allows energy to be transferred to the output winding while the core is acting as a transformer. The Milgo MN11 operates equally well on a power supply voltage of -20v instead of -25v as described.

2-3. SHIFT REGISTERS

a. When connected to form a shift register, MN11 cores are connected as shown in Figure MN-3. If a positive going pulse is applied to pin 8 of the first core, a "1" will be inserted into that core. During the next core drive pulse, all of the cores will be pulsed simultaneously, since they are connected in parallel. The resultant 9v pulse from the advance winding of the first core will charge the capacitor in the first core to approximately -16v. When the first core has switched from minus saturation to plus saturation, there will no longer be any voltage generated in the advance winding. CR3 of the first core will prevent the capacitor from discharging through the advance winding, however, and CR2 in the second core prevents this capacitor from discharging through the input winding of the second core. CR2 is reverse biased because of the IR drop in the resistor of the second core caused by the shift current.

g. When the shift pulse has passed, the pin 2 voltage of the second core will go back to -25v and the capacitor in the first core may now discharge through the input winding of the second core. The resultant current through the input winding is sufficient to drive the second core from point D to point G on the saturation curve, so that when C3 is completely discharged, the second core will be in a "1" state. While this second core was being switched from plus saturation to minus saturation, flux linkages were changing in all of the windings of this core, with the result that a voltage was generated in all of these coils with the dot end of the winding negative. Diode CR1 will prevent any current flow in the drive winding as a result of the generated voltage, and the diode CR3 will prevent any current flow in the advance winding as a result of this generated voltage.

h. During the next core drive pulse, core 2 is switched from minus saturation to plus saturation, resulting in the output capacitor of the second core being charged. After the second core drive pulse, the discharge current from this capacitor will insert a "1" into the third core and so on to the last one. Since both ends of the auxiliary winding are brought out, the auxiliary winding may be used to generate either a positive going or negative going 9v pulse. This auxiliary pulse will be approximately 9v in magnitude, with a rise time of six microseconds and a fall time of approximately one half microsecond. In addition, the auxiliary winding can be used to insert "1's" into the core by applying a suitable positive pulse to pin 5 or a suitable negative pulse to pin 4. Pins 2, 3, and 6 are brought out for additional flexibility in adapting the MN11 core to logic circuits.

2-4. BLOCKING OSCILLATORS

a. The use of transformers for blocking oscillators is common and widely understood. It is also possible to use a square loop magnetic core as a blocking oscillator transformer with some desirable results in control of pulse width. Figure MN-4 shows the connections of either an MN12 or an MN13 as used in a blocking oscillator.

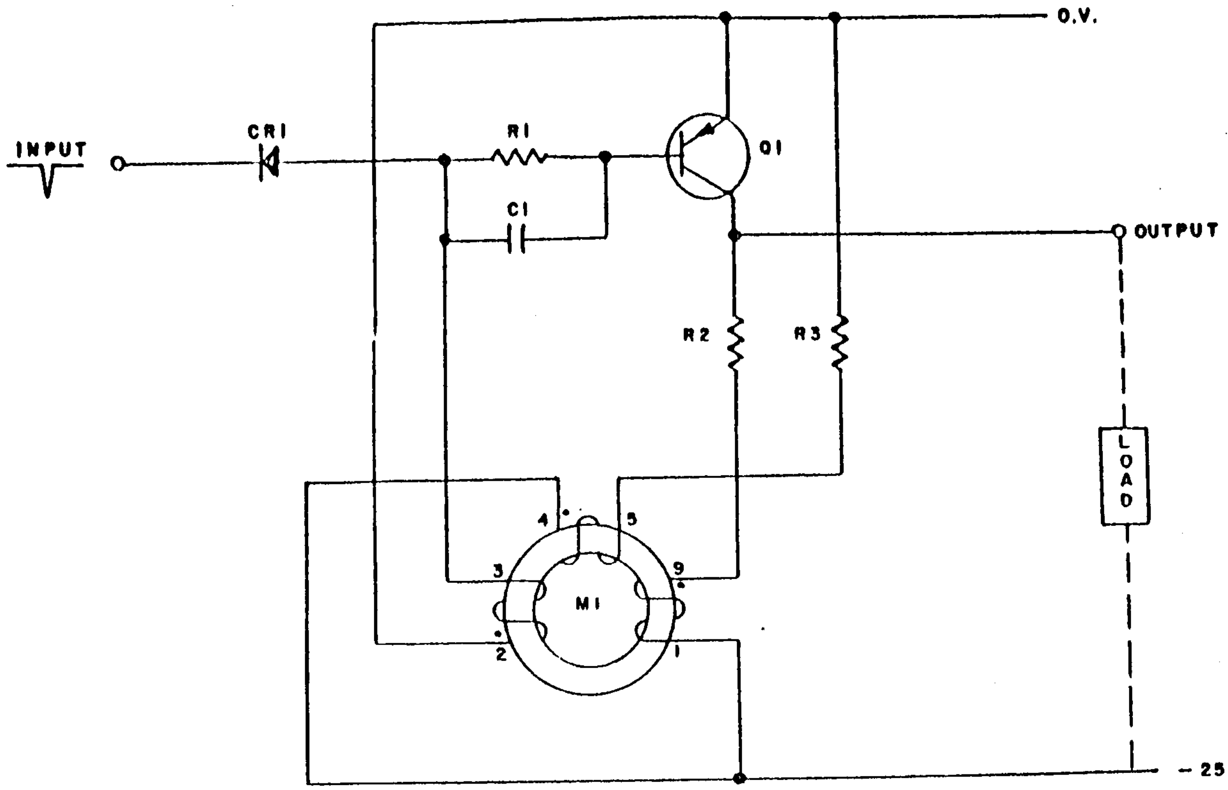


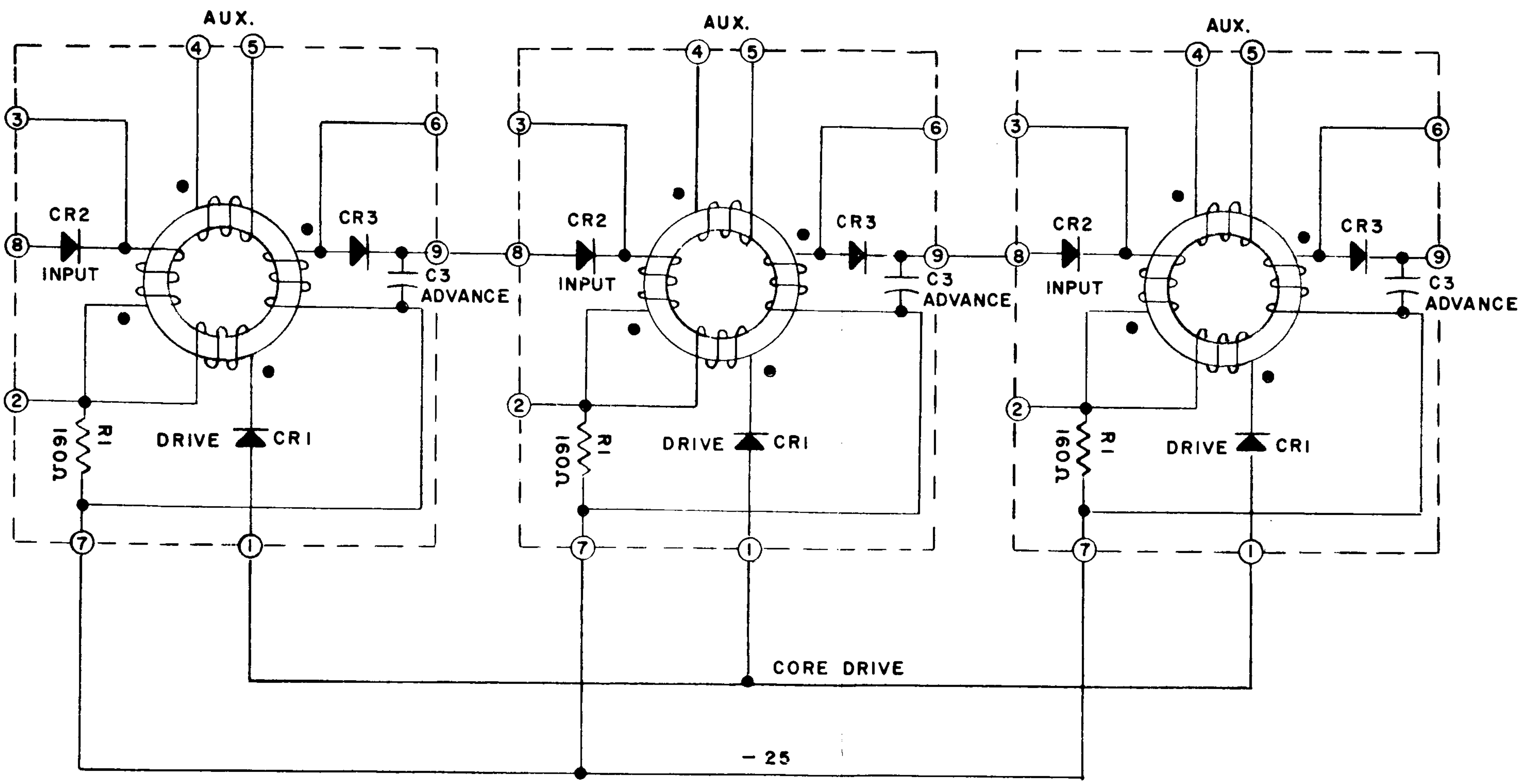
Figure MN-4. Blocking Oscillator (MN12 or MN13)

b. The 9-1 winding is the collector winding and could be compared to the primary winding of a transformer. The 2-3 winding is the feedback winding and could be compared to the secondary winding of a transformer. The 4-5 winding is the reset winding and has no counterpart in a conventional transformer. The reset winding is so connected that the current through the reset winding will drive the core into negative saturation. The transistor will normally be cut off, but when triggered by a negative pulse at the input, will go into conduction. The resulting collector current applies positive ampere-turns to the core and the flux moves from H toward A and B. The resulting flux change in the core is sensed by the feedback winding and a voltage is generated, making pin 3 negative. This negative going voltage is applied to the base of the transistor and drives the transistor into heavier conduction.

c. As the transistor conducts more heavily, the rate of change of flux increases, resulting in an even more negative voltage being applied to the base of the transistor. This feedback very quickly saturates the transistor (approximately one microsecond), but the collector current is limited by resistor R2 and the voltage generated in the collector winding of the core. As long as the core is still in the process of switching from minus saturation to plus saturation, the core and its windings act as a transformer and the feedback winding continues to drive the transistor into saturation. When the core has finally reached saturation (B on hysteresis curve, Figure MN-1), additional ampere-turns from the collector winding will no longer result in a change of flux and no additional voltage will be generated in the feedback winding. This removes the drive to the transistor, which immediately cuts off, removing the ampere-turns from the collector winding.

d. Current through resistor R3 and the reset winding now starts to apply ampere-turns in the negative direction again and drives the core from position D to F. This results in a reversal of flux in the core, which reverses the voltage generated in the feedback winding. Pin 3 now becomes slightly positive, insuring a rapid cutoff of the transistor. Since the duration of the output pulse depends on the time it takes to switch the magnetic core, the pulse width depends on the core used and is relatively independent of the load on the blocking oscillator.

e. Two blocking oscillator cores are used in Milgo equipment: an MN12 and an MN13. The MN12 will cause a pulse approximately 10 microseconds wide to be generated by the blocking oscillator, while the MN13 will cause a pulse approximately 40 microseconds wide to be generated. It takes approximately 30 microseconds to reset an MN12 core and approximately 80 microseconds to reset an MN13 core.


AUX.
4
5
3
6
CR2
CR3
8
9
INPUT
C3
ADVANCE
2
R1
160Ω
DRIVE
CR1
7
1
AUX.
4
5
3
6
CR2
CR3
8
9
INPUT
C3
ADVANCE
2
R1
160Ω
DRIVE
CR1
7
1
AUX.
4
5
3
6
CR2
CR3
8
9
INPUT
C3
ADVANCE
2
R1
160Ω
DRIVE
CR1
7
1
CORE DRIVE
- 25